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THE UNIVERSITY OF KANSAS CENTER FOR RESEARCH, INC.

2291 Irving Hill Drive—Campus West
Lawrence, Kansas 66045

**THE DEVELOPMENT OF METHODS FOR THE
PREDICTION OF PRIMARY CREEP
BEHAVIOR IN METALS**

Final Report

Submitted by

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LIST OF PRINCIPAL SYMBOLS

a_{σ}	free energy and entropy nonlinearity in TC equations
b	constant in solution for a_{σ}
B_{time}	time adjustment factor representing difference between actual and apparent starting points of creep
C'	constant in power law equation
C_0	constant in TC recovery equation
C_1	linear creep compliance in TC equations
C_1'	modified linear creep compliance
C_s	constant representing steady state creep rate
C_{end}	parameter in modified recovery equation representing the nonrecoverable portion of creep
D_0	linear elastic compliance
$\Delta D(\psi)$	linear creep compliance function
g_0, g_1, g_2	free energy nonlinearities in TC equations
$H(\tau)$	Heavyside function
n	exponent in power law equation
p	constant in solution for a_{σ}
R	gas constant
RSS	residual sum of the squares
r	exponent in exponential law equation
SC	serial correlation
T	temperature
T_h	homologous temperature
TC	thermodynamic constitutive
t_0	time at beginning of creep test
t_a	time at removal of load or beginning of recovery
$\delta(\tau)$	Dirac delta function

ϵ	strain
ϵ_0	elastic strain
ϵ_r	recovery strain from data
$\dot{\epsilon}_s$	steady state creep rate
$\Delta\epsilon_1$	strain drop upon removal of load at end of creep test
λ	reduced time
λ_r	reduced time from data
σ	stress
σ_0	constant stress
τ	arbitrary time
ψ, ψ'	reduced times

ABSTRACT

The applicability of a thermodynamic constitutive theory of deformation to the prediction of primary creep and creep strain relaxation behavior in metals is examined. Constitutive equations derived from the theory are subjected to a parametric analysis in order to determine the influence of several parameters on the curve forms generated by the equations. A computer program is developed which enables the solution of a generalized constitutive equation using experimental data as input. Several metals were tested to form a data base of primary creep and relaxation behavior. The extent to which these materials conformed to the constitutive equation showed wide variability, with the alloy Ti-6Al-4V exhibiting the most consistent results. Accordingly, most of the analysis is concentrated upon data from that alloy, although creep and relaxation data from all the materials tested are presented. Experimental methods are outlined as well as some variations in methods of analysis. Various theoretical and practical implications of the work are discussed.

INTRODUCTION

A major problem encountered in predicting primary creep behavior in metals and alloys has been the lack of generality of the available constitutive equations. A particular equation is typically applicable to just a few metals, or restricted to narrow ranges of temperature, applied stress, and deformation. In addition, most of the constitutive equations are completely empirical, and so have no real basis in the microscopic mechanisms that might be rate controlling during primary creep.

Preliminary investigation of the scope of the problem quickly demonstrated that a new approach was needed. One possible avenue of investigation was a thermodynamic constitutive (TC) theory of deformation [1,2,3,4] based upon the application of nonequilibrium thermodynamics to deformation processes in solids. The TC theory had been successful in describing creep and strain relaxation behavior in several nonmetallic systems [5], and application of the methods of the theory to a few metals showed that it might be generally useful in metallic systems as well [6]. A further encouraging aspect was that certain fundamental parts of the TC theory could be rationalized within the framework of dislocation dynamics [6,7] even though the development of the theory was essentially phenomenological. Based upon this evidence, the central objective of the work reported herein was to determine if the TC theory, or a suitable modification, could be used as a basis for a generalized constitutive equation that would be descriptive of primary creep and creep-strain relaxation behavior in several important metals and alloys.

In Figure 1, schematic creep and creep-strain relaxation curves are shown. The initial load is applied at time t_0 , and is removed at time t_a for a relaxation test. During creep, the load is constant, as is the temperature. The purpose of the analytical and experimental efforts of this project was to develop an equation (or equations) that would accurately predict the characteristics shown in Figure 1 in a variety of metals.

This report is divided into three principal sections. The first section is analytical in nature, and provides a theoretical background for the work. Also provided are the details of a parametric analysis of the equation forms, solution methods, and the applicable computer

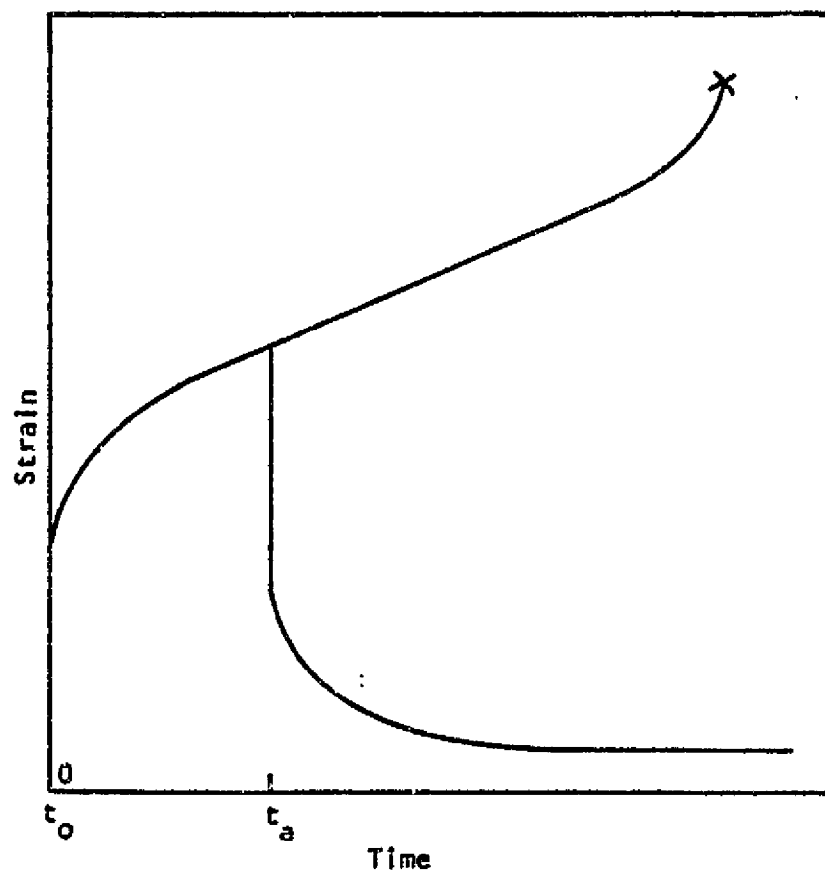


Figure 1. Schematic creep curves for a material subject to constant stress at time t_0 and unloaded at time t_a .

programs that were developed. In the second section, the testing procedures are outlined, and the results of primary creep and relaxation tests for several metals are given.

Since Ti-6Al-4V gave the most consistent results with respect to the constitutive equations developed, a detailed analysis of the data for this alloy is carried out. In particular, the influence of temperature and stress level on the parameters of the constitutive equation is examined in detail.

The final section of this report is a discussion of the results and analysis, particularly with regard to possible microscopic mechanisms that might be operable during creep. Conclusions relating to the applicability of the TC theory to primary creep prediction are also advanced.

THE CONSTITUTIVE EQUATIONS

Descriptive Equations

Three general empirical equations have been used to describe primary creep. They are the power law equation, the exponential equation and the logarithmic creep equation.

The power law or parabolic equation has the form

$$\epsilon = \epsilon_0 + \text{Const. } t^n \quad (1)$$

where ϵ_0 is the initial elastic strain and n varies between .03 and 1. The power law has been found [5] to fit a wide variety of experimental creep curves in both metals and nonmetals.

The exponential equation is of the form

$$\epsilon = \epsilon_0 + \epsilon_t (1 - e^{-rt}) \quad (2)$$

where ϵ_t is the total primary strain. The exponential equation is widely used and fits a variety of creep curves.

The logarithmic relation is

$$\epsilon = \epsilon_0 + \alpha \ln(1 + vt). \quad (3)$$

The logarithmic relation will generally not fit above $.3 T_h$.

When secondary creep exists, an additional term is sometimes added to these equations. With this addition the power law equation would be

$$\epsilon = \epsilon_0 + \text{Const } t^n + \dot{\epsilon}_s t \quad (4)$$

where $\dot{\epsilon}_s$ is the secondary creep rate.

Creep and recovery can be broadly viewed as a combination of elastic and viscous flow. This allows the application of the phenomenological theory and mathematics of viscoelasticity to creep and recovery.

Creep strain can be represented as a generalized function

$$\epsilon = F(\sigma_0, t) \quad (5)$$

where σ_0 is a constant stress and is applied at $t = 0$. If strain is a linear function of stress the equation can be modified to

$$\epsilon = F(t)\sigma_0 = F(0)\sigma_0 + [F(t) - F(0)]\sigma_0 \quad (6)$$

where $F(0)\sigma_0$ is the initial elastic strain. An arbitrary stress input can be defined by

$$\sigma(t) = \int_{-\infty}^{\infty} H(t - \tau) \dot{\sigma}(\tau) dt \quad (7)$$

where τ is a dummy time representing past time and $H(t)$ is the Heavyside unit function. Since the function $H(t - \tau)$ is always unity in the range of integration, the strain can be written

$$\epsilon = F(0)\sigma_0 + \int_{-\infty}^{\infty} F(t - \tau) \dot{\sigma}(\tau) dt \quad (8)$$

This is the Boltzman superposition integral and is a basic equation for linear viscoelasticity. It provides a good fit to some creep data but generally is difficult to fit to recovery data.

As noted, each equation form has some merit. However, for most metals subjected to stresses and temperatures where creep can operate, the power law equation (or a modification thereof) has been found to have the widest range of applicability. In addition, this particular equation form can be related to dislocation velocities and densities in crystalline materials because of the influences of these parameters on strain rate (creep rate) at constant stress and temperature. Accordingly, the development of a generalized constitutive equation that would describe primary creep behavior was based upon merging the well-established power law equation with the TC theory. Of equal validity, however, would be using any of the other equation forms because there is no restriction in this regard in the TC theory. Doing this would simply result in constitutive equations with a smaller range of applicability. Accordingly, the derivation in the following section uses only the power-law form, which is retained (with some modification) throughout the body of this work.

Derivation of the Constitutive Equation

The derivation of the Thermodynamic Constitutive (TC) theory begins with an equation for entropy production derived by Schapery in [1]

$$\frac{dS}{dt} = \frac{1}{T} \left(Q_i - \frac{\partial F}{\partial q_i} \right) \frac{dq_i}{dt} \geq 0 \quad (9)$$

where S is entropy, t is time, F is the Helmholtz free energy, q_i represents i generalized coordinates (such as strain), and Q_i represents i generalized forces (such as stress) conjugate to q_i . F is a function of q_i and temperature and the incremental amount of work done is defined as

$$\partial W_i = Q_i dq_i \quad (10)$$

The coordinates are further divided into two groups of hidden and observed. Hidden coordinates are defined by the condition that their conjugate forces are always zero. Hidden coordinates may be considered to represent the action of lattice distortions, grain boundary sliding, twinning, etc.

Schapery in [2] uses equation (9) to derive a general equation relating forces, coordinates and temperature

$$\frac{\partial F}{\partial q_i} + a_D b_{ij} \frac{dq_j}{dt} = Q_i \quad (11)$$

where a_D is a factor which contains all nonlinearity arising from entropy production and, as a consequence of Onsager's principle, b_{ij} is a positive symmetric, constant, semidefinite matrix.

When equation (11) is combined with an expression for the Helmholtz free energy the following equation is derived

$$\sum_{j=1}^n a_{ij} q_j + \sum_{j=1}^n b_{ij} \frac{dq_j}{d\rho} = Q_i - \frac{\partial \Delta F_e}{\partial q_i} \quad (12)$$

where a_{ij} is a function of free energy and ρ is a reduced time defined by

$$\rho = \int_0^t \frac{dt}{a_\epsilon} \quad (13)$$

For uniaxial loading there is only one generalized force, Q_1 , and one coordinate, q_1 , and stress is equal to

$$\sigma = Q_1 \frac{dq_1}{d\epsilon} \quad (14)$$

The following equation may then be found from (12):

$$\sigma = \frac{d\Delta F_e}{d\epsilon} + \frac{dq_1}{d\epsilon} \int_0^t E(\rho - \rho') \frac{dq_1}{d\tau} d\tau \quad (15)$$

$E(\rho)$ is the strain reduced time, τ is an arbitrary time and

$$\rho' = \int_0^t \frac{dt}{d\epsilon}$$

This is the equation for constant strain rate creep. (16)

Schapery in [3] and [4] uses the Gibbs free energy and a derivation similar to that above to derive an equation for uniaxial loading with strain as a function of stress. This is

$$\epsilon = - \frac{dG_R}{d\sigma} + \frac{d\hat{Q}_1}{2\sigma} \int_{-\infty}^t \Delta D(\psi - \psi') \frac{d(\frac{\hat{Q}_1}{a_G})}{d\tau} d\tau \quad (17)$$

where G_R is the Gibbs free energy of the hidden coordinates and $\hat{Q}_1$ is the nonlinearity in the stress related to second order changes in the Gibbs free energy with respect to hidden coordinates and observed forces and is a function of stress and temperature. $D(\psi)$ is the linear viscoelastic creep compliance and a_G is a nonlinearity factor arising from second order changes in the free energy with respect to hidden coordinates and is a function of stress and temperature. The reduced times, ψ and ψ' , are defined as

$$\psi = \int_0^t \frac{a_G}{a_D} dt \text{ and } \psi' = \int_0^{\tau} \frac{a_G}{a_D} dt \quad (18)$$

where a_D is a factor containing all nonlinearity arising from entropy production.

Equation (17) can be rewritten into a form of the basic equation used by Schapery and Lou in [8] as

$$\epsilon = g_0 D_0 \sigma + g_1 \int_0^t \Delta D(\psi - \psi') \frac{dg_2 \sigma}{d\tau} d\tau. \quad (19)$$

The reduced times are now

$$\psi = \int_0^t \frac{dt}{a_\tau} \quad \text{and} \quad \psi' = \int_0^\tau \frac{dt}{a_\sigma} \quad (20)$$

and the four independent nonlinear material parameters are

$$g_0 = - \frac{dG_R}{D_0 \sigma d\sigma} \quad (21)$$

$$g_1 = \frac{d\hat{Q}_1}{dQ_1} \quad (22)$$

$$g_2 = \frac{\hat{Q}_1}{\sigma a_G} \quad (23)$$

$$a_\sigma = \frac{a_G}{a_D} \quad (24)$$

D_0 is the linear elastic compliance and is equal to the inverse of the modulus of elasticity.

When $g_0 = g_1 = g_2 = a_\sigma = 1$ equation (19) reduces to the Boltzman superposition integral in equation (8).

Solution for Constant Load

For a uniaxial stress input of σ_0 at time $\tau = 0$, the following relations are defined:

the Heavyside function with

$$H(\tau - 0) = \begin{cases} 0, & \tau < 0 \\ 1, & \tau > 0 \end{cases} \quad (25)$$

and

the Dirac delta function

$$\delta(\tau - 0) = \frac{d H(\tau - 0)}{d\tau} = \begin{cases} \infty & \tau = 0 \\ 0 & \tau \neq 0 \end{cases} \quad (26)$$

where

$$\int_{-\infty}^{\infty} \delta(\tau) d\tau = 1 \quad (27)$$

In equation (19) if g_2 and a_σ are assumed to be functions of stress only, then for the given step input at $\tau = 0$

$$\epsilon = g_0 D_0 \sigma_0 + g_1 \int_0^t \Delta D(\psi - \psi') \frac{g_2 \sigma_0 dH(\tau - 0)}{d\tau} d\tau \quad (28)$$

or

$$\epsilon = g_0 D_0 \sigma_0 + g_1 g_2 \sigma_0 \int_0^t \Delta D(\psi - \psi') \delta(\tau - 0) d\tau \quad (29)$$

Since the Dirac delta function causes the integral to be zero everywhere except at $\tau = 0$, $D(\psi - \psi')$ is independent of the integral and is defined only at $\tau = 0$. Thus

$$\psi = \frac{1}{a_\sigma} \int_0^t dt = \frac{t}{a_\sigma} \quad \text{and} \quad \psi' = \frac{1}{a_\sigma} \int_0^\tau dt = 0 \quad (30)$$

and

$$\epsilon = g_0 D_0 \sigma_0 + g_1 g_2 \sigma_0 \Delta D\left(\frac{t}{a_\sigma}\right) \int_0^t \delta(\tau) d\tau \quad (31)$$

which, by equation (27) is

$$\epsilon = g_0 D_0 \sigma_0 + g_1 g_2 \Delta D\left(\frac{t}{a_\sigma}\right) \sigma_0 \quad (32)$$

The equation for recovery can be similarly solved for an input of

$$\sigma(t) = \begin{cases} \sigma_0 & 0 < t < t_a, \text{ or } \sigma_0 H(\tau) \\ 0 & t_a < t, \text{ or } (0) H(\tau - t_a) \end{cases} \quad (33)$$

at $\sigma(t) = 0$, g_0 , g_1 , g_2 , and a_σ are assumed to be equal to one. This results in the equation for creep recovery, ϵ_r , beginning at time t_a

$$\epsilon_r = g_2 \sigma_o [\Delta D(\frac{t}{a_\sigma} + t - t_a) - \Delta D(t - t_a)] \quad (34)$$

The form of the creep compliance function, ΔD , is not derived by Schapery. In [5] he discussed the form of this function and indicates the power law should apply for most materials where

$$\Delta D(\psi) = C_1 \psi^n \quad (35)$$

where C_1 and n are constants.

Using the power law, equation (32) for creep can be written

$$\epsilon = g_o D_o \sigma_o + g_1 g_2 C_1 (\frac{t}{a_\sigma})^n \sigma_o \quad (36)$$

and equation (34) for recovery would be

$$\epsilon_r = g_2 \sigma_o [C_1 (\frac{t_a}{a_\sigma} + t - t_a)^n - C_1 (t - t_a)^n] \quad (37)$$

or with some rearrangement

$$\epsilon_r = g_2 \sigma_o (\frac{t_a}{a_\sigma})^n C_1 [(1 + a_\sigma \lambda)^n - (a_\sigma \lambda)^n] \quad (38)$$

where λ is a reduced time equal to

$$\lambda = \frac{t - t_a}{t_a} \quad (39)$$

and C_1 is the linear creep compliance.

Equations (36) and (38) are limited to small strains, where the true strain and engineering strain are essentially equal. This condition is easily fulfilled for primary creep in metals because the strain is generally much less than 1%. Changes in stress, temperature, and microstructure are reflected by changes in the parameters.

Parametric Analysis

As previously stated, all of the nonlinearity parameters are defined as being equal to one at zero stress.

The effect of g_0 is in the initial elastic compliance of the material, as illustrated in Figure G0-1*. Increasing the value of g_0 while holding all the other parameters constant shifts the creep curve upwards.

The equation for the strain drop, $\Delta\epsilon$, when the load is removed to begin recovery is

$$\Delta\epsilon = g_0 D_0 \sigma_0 + g_2 C_1 \sigma_0 \left(\frac{t_a}{a_\sigma} \right)^n (g_1 - 1) \quad (40)$$

where t_a is the time at which the load is removed.

The g_1 parameter represents a measure of the nonlinearity in the creep compliance. As can be seen from equation (40) it affects the strain drop upon removal of the load. Figure G1-2 indicates that all of the extra creep resulting from the nonlinearity in g_1 is "recovered" in the elastic strain drop. It has no effect on the recovery curve. It cannot be much less than 1 as it will cause an increase in the strain drop as is indicated on line one of Figure G1-2. When g_1 is equal to 1 the strain drop is equal to the initial elastic strain. Equation (22) indicates that g_1 can be viewed as a nonlinearity in the applied load during creep.

The g_2 parameter represents a viscoelastic nonlinearity in the creep compliance. It affects both creep and recovery and affects the strain drop as a function of g_1 . The extra strain occurring during creep is recovered later, as indicated on Figure G2-1, after unloading.

The material constant, D_0 , is the linear elastic compliance of the material. It is constant for any given temperature. Its effect is indicated on Figure G0-1.

The material constant C_1 is the linear viscoelastic compliance and is constant for any given temperature. Its effect can be seen in Figure G1-1. It increases the amount of creep and recovery and affects the strain drop as a function of g_1 . It has no effect on the elastic strain.

The effect of a_σ can be seen in Figures ENT-1 and ENT-1L where ENT refers to entropy and L refers to large deviations in a_σ . The

*These figures are located alphabetically at the end of Appendix A.

effect of a_σ on the creep curve is to decrease the amount of creep, thus a decrease in a_σ will cause an increase in the creep. On the recovery curve a_σ increases the rate of recovery. As can be seen from equation (36) a_σ acts as a time shift factor, so that a decrease in a_σ extends the recovery curve so that there is less actual recovery for a given time. On a log-log plot of strain vs. reduced time, λ , the value of a_σ is represented by a horizontal shift of the curve. As can be seen from Figures ENT-2L and ENT-3L very small values of a_σ can be used to simulate recovery curves that do not return to zero.

The effect of the exponent, n , is indicated in Figure EXP-1. The effect of n is on the initial rate of curvature, with lower values of n increasing the rate of curvature. The maximum possible value of n is 1, this represents a straight, zero slope line during recovery.

The effect of stress is indicated on Figure STS-1.

Figure SIM-1 contains a simulation of an actual series of creep tests. This is obtained by varying both a_σ and stress. Note that this appears to account for plastic deformation.

SOLUTION OF THE CONSTITUTIVE EQUATIONS

The following sections demonstrate procedures that can be used to solve the constitutive equations for values of the parameters using experimental data as input. In the example solutions, a single data set is used. The test was on a Ti-6Al-4V titanium alloy at 440°C at a stress level of 161 MPa. This particular test was in the lower ranges of both stress and temperature used in the total creep study of the alloy. The duration of the test was 357 minutes. Of this, the first 119 minutes of the test were creep and the last 238 minutes were relaxation (strain recovery after load removal). A plot of the creep and recovery data is given in Figure 2. The details of the experimental procedures used for this test and others are presented in a later section.

Graphical Solution

Schapery and Lou in reference [8] solve the constitutive equations using a curve shifting method. The equation for recovery is

$$\epsilon_r = C_0 [(1 + a_\sigma \lambda)^n - (a_\sigma \lambda)^n] \quad (41)$$

where

$$C_0 = g_2 C_1 \left(\frac{t_a}{a_\sigma}\right)^n \sigma_0 \quad (42)$$

The values of n , a_σ , and C_0 are solved first by plotting ϵ_r vs. λ on log-log paper as on Figure 3. This graph is then compared visually to the "master curve" plot on Figure 4 for the equation

$$\epsilon_r = [(1 + \lambda)^n - (\lambda)^n] \quad (43)$$

where n is varied to produce the different curves. The experimental data on Figure 3 is physically shifted both vertically and horizontally over the master curves until the best possible match between it and one of the master curves is found. The n of the master curve is then the n of the data. In this case n was found to be 0.25. Due to the small recovery strains and the similarity in the master curves it is difficult to find an accurate best fit. In this case the accuracy of n is estimated to be 20%.

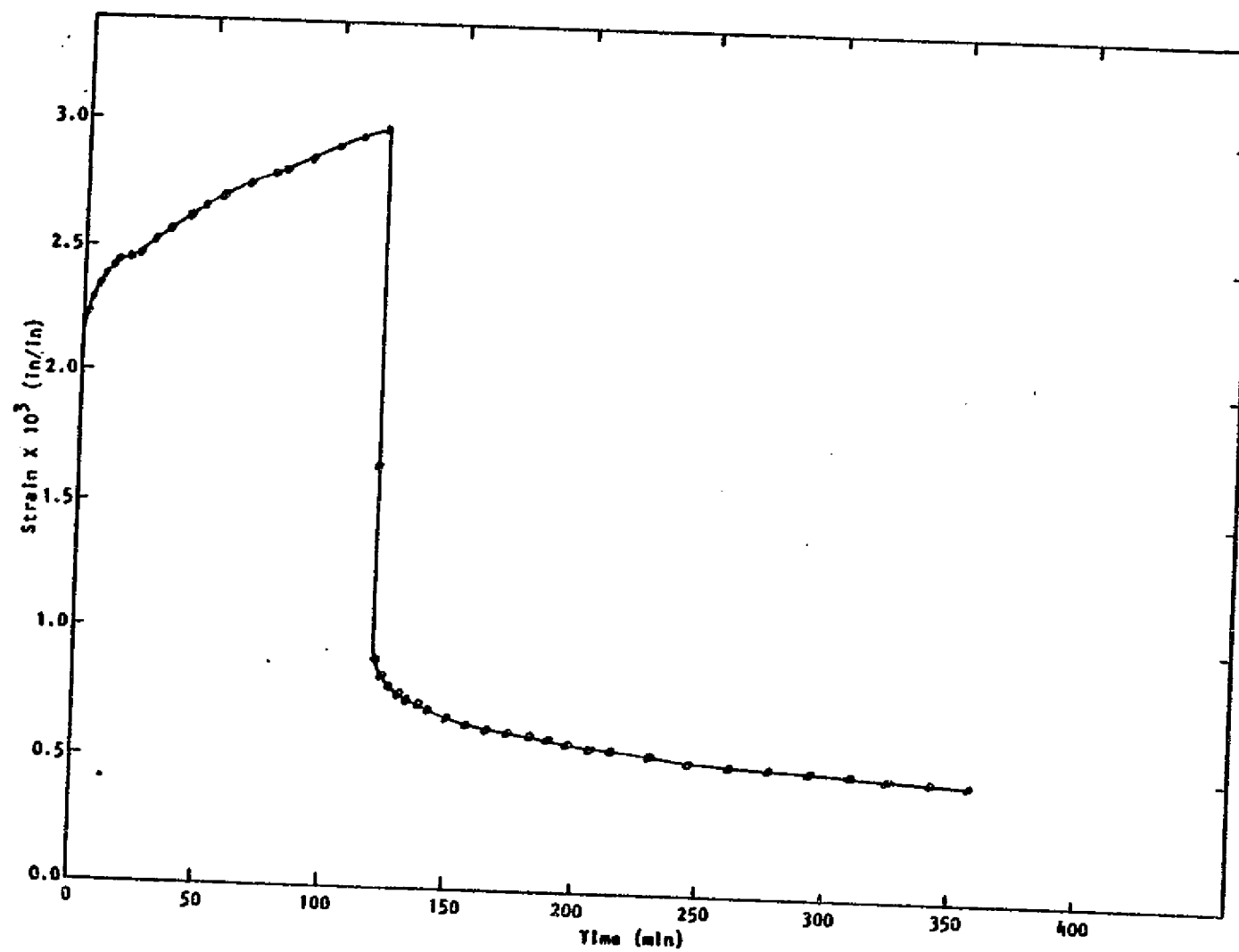


Figure 2. Creep and recovery strain vs time for Ti-3 test

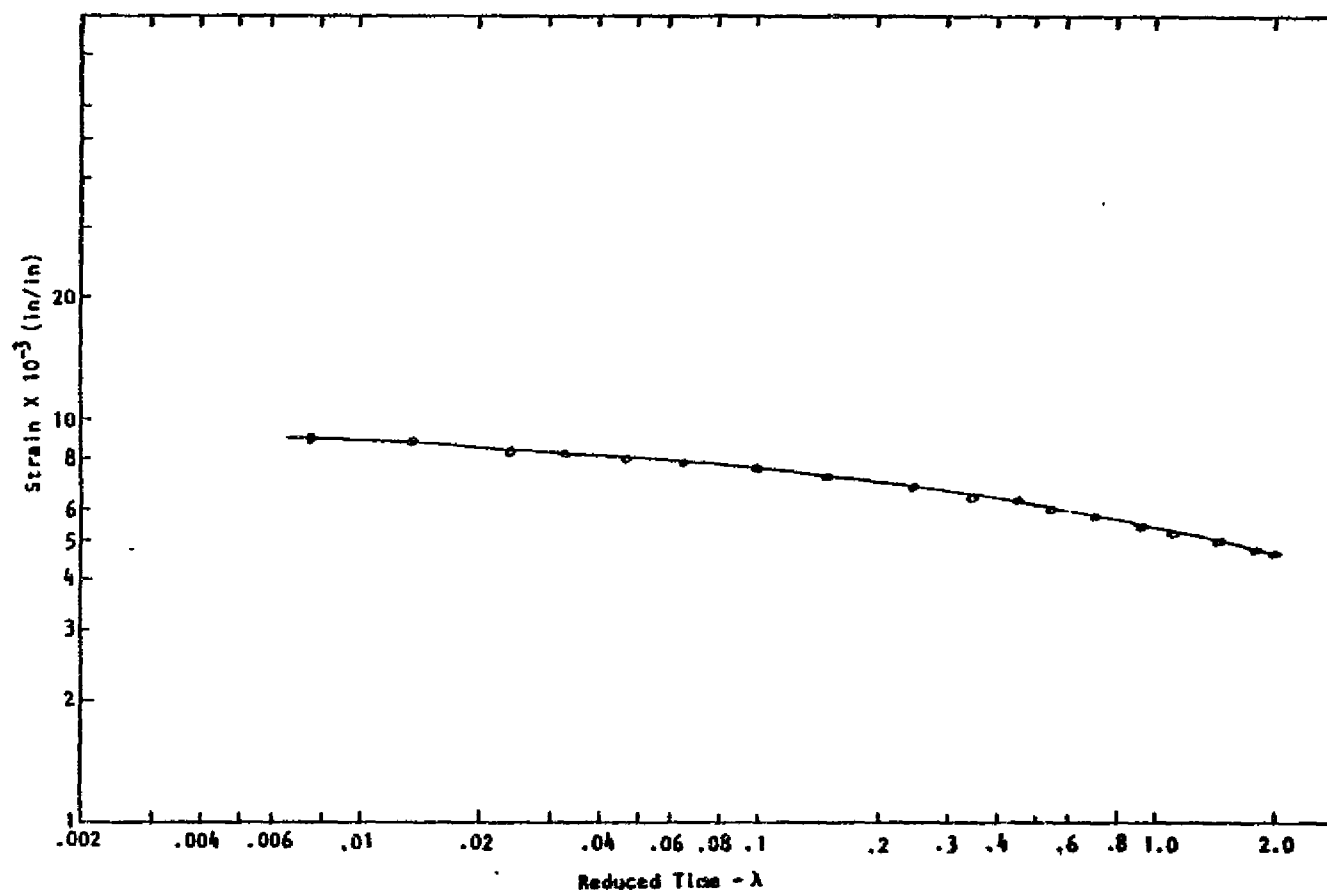


Figure 3. Log-log plot of recover; strain vs reduced time for Ti-3 data

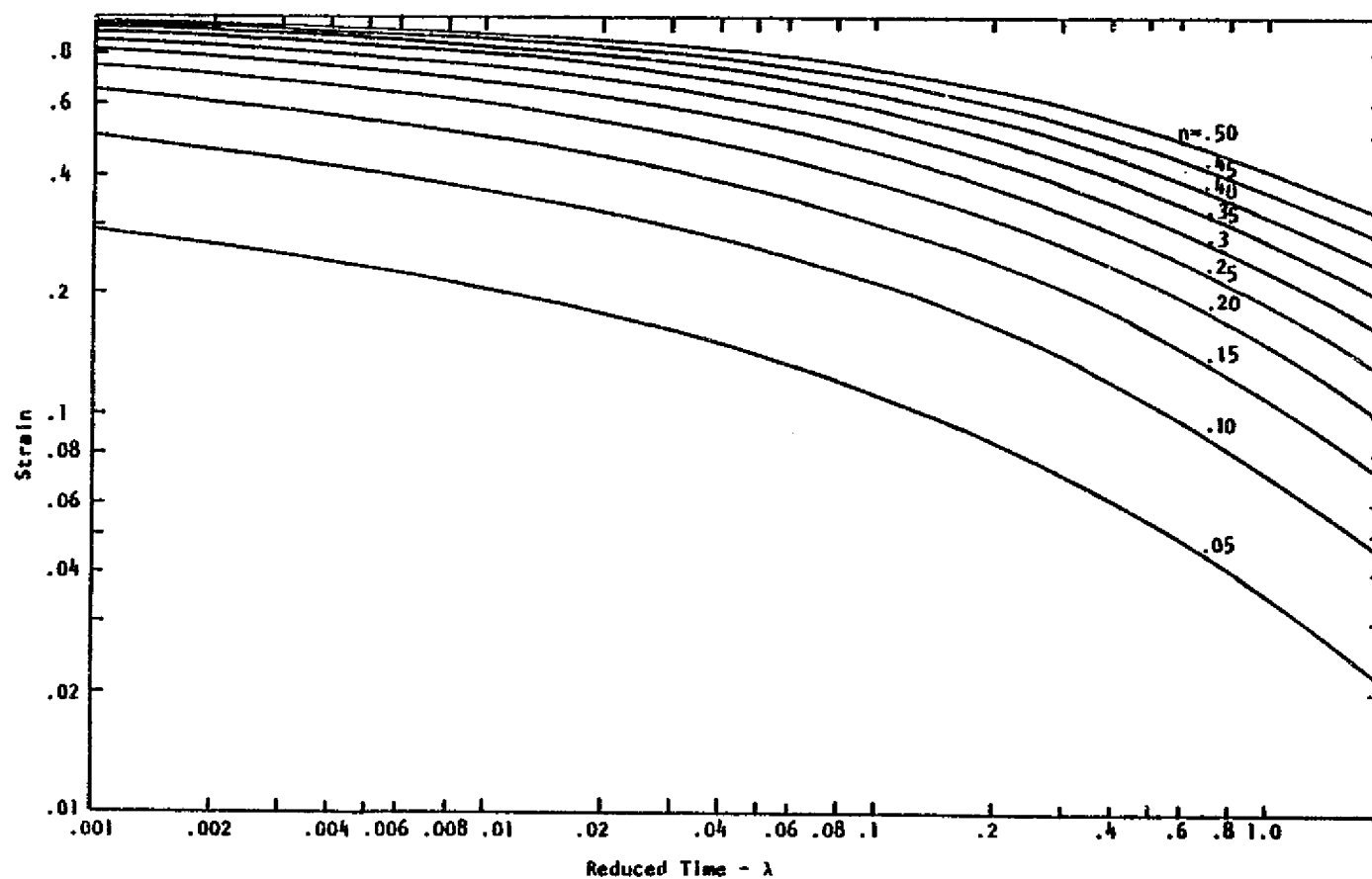


Figure 4. Master curves for equation (43)

The a_σ parameter is determined from the amount of horizontal shift. For this a λ value is picked on the master curve and then the λ_r value over that point is read from the data curve. Then

$$a_\sigma = \frac{\lambda}{\lambda_r} = \frac{.100}{1.70} = .0588 .$$

In the same manner, for C_0 a value of strain, ϵ , is picked on the master curve and the value of strain, ϵ_r , occurring over that point from the data curve is recorded. Then,

$$C_0 = \frac{\epsilon_r}{\epsilon} = \frac{.21 \times 10^{-3}}{.20} = .00105 .$$

Next the value of ϵ_0 , the initial elastic strain, and C' are determined for the equation

$$\epsilon = \epsilon_0 + C' t^n \quad (44)$$

where

$$\epsilon_0 = g_0 D_0 \sigma_0 \quad (45)$$

and

$$C' = g_1 g_2 C_1 \left(\frac{1}{a_\sigma} \right)^n \sigma_0 \quad (46)$$

Selecting two data points

$$t_1 = 9.143 \quad \text{at} \quad \epsilon_1 = 2.3986 \times 10^{-3} \quad \text{and}$$

$$t_2 = 85.143 \quad \text{at} \quad \epsilon_2 = 2.8299 \times 10^{-3}$$

and solving for C' with $n = .25$

$$C' = \frac{\epsilon_1 - \epsilon_2}{t_1^{.25} - t_2^{.25}} \quad (47)$$

$$C' = .3321 \times 10^{-4}$$

and

$$\epsilon_0 = \epsilon_1 - C' \times t_1^{.25}$$

$$\epsilon_0 = 1.821 \times 10^{-3}$$

$\Delta\epsilon_1$ is the total amount of creep, excluding the initial elastic strain, that occurs during the creep test. For a total creep time, t_c , of 119.8 min.

$$\Delta\epsilon_1 = C' \times t_c^n \quad (48)$$

or

$$\Delta\epsilon_1 = 0.001097$$

Next

$$g_1 = \frac{\Delta\epsilon_1}{\epsilon_0} \quad (49)$$

$$g_1 = 1.045$$

Next solve for g_0 where

$$g_0 = \epsilon_0 / \sigma_0 \times D_0 \quad (50)$$

where D_0 is the reciprocal of E , the modulus of elasticity. Thus

$$g_0 = 0.001821 \times 11.07 \times 10^6 / 23400$$

$$g_0 = 0.86147$$

Next solve for the product of the creep compliance, C_1 , and g_2

$$C_1 g_2 = \frac{C' \times a_{\sigma}^n}{g_1 \times \sigma_0} \quad (51)$$

$$= \frac{(3.321 \times 10^{-4}) (.0588)^{.25}}{(23400) (1.045)}$$

$$C_1 g_2 = 6.6712 \times 10^{-9}$$

In a series of creep tests at a given temperature g_2 would be assumed to be 1 at the lowest stress, and thus $C_1 g_2$ would be the linear viscoelastic creep compliance, C_1 .

Computer Solution

The solution of the recovery equation by the graphical (curve-shifting) method is rather difficult and inexact for small strains, so that the solution for the parameters of the creep equation is at best an approximation. A BMDP3R computer program was employed for the purpose of overcoming these problems. The program is a multivariable, nonlinear, least squares regression program that is maintained by the University of Kansas Computation Center. Its application to this work is discussed in detail in Appendix 8.

The computer approach is useful because it is much more accurate than the curve shifting solution, providing repeatable and consistent solutions of the data. The precision of the values of the parameters calculated from the program are typically well within 10%, whereas the values from the curve shifting procedure are estimated to be within 5-20% of the best value. As well as being faster for reducing the data of several test runs, the program also uses 20-40 data points to solve for the parameters rather than the two used in the solution of ϵ_0 and C' by the curve shifting method. The program provides indications of the quality of fit of the calculated curve to the data as well as the standard deviations of the parameters calculated, and it allows easy use and evaluation of modifications or improvements to the TC theory.

In the solution of the TC theory the computer is used first to solve for n , a_0 , and C_0 from the recovery data, and then to solve for ϵ_0 and C' from the creep data using the n previously calculated from the recovery data. Using the BMDP3R program and the recovery data, the variables in the recovery equation are found to be

$$n = 0.23686 \pm 0.017$$

$$a = 0.05259 \pm 0.00668$$

$$C_0 = 1.0535 \times 10^{-3} \pm 0.0254 \times 10^{-3}$$

Then using $n = 0.23686$ and the creep data the computer solves for

$$\epsilon_0 = 1.70717 \times 10^{-3}$$

$$C' = 0.39222 \times 10^{-3}$$

Then using the same procedure as before for the curve shifting method

$$\Delta\epsilon_1 = .39222 \times 10^{-3} (119.8) \cdot 23696$$

$$\Delta\epsilon_1 = .001222$$

$$g_1 = .001222 / .00105$$

$$g_1 = 1.1601$$

$$g_0 = .001707 \times 11.07 \times 10^6 / 23400$$

$$g_0 = .80761$$

$$C_1 g_2 = \frac{(.0003933)(.05259) \cdot 25696}{(23400)(1.1601)}$$

$$C_1 g_2 = 7.210 \times 10^{-9}$$

The computer provides a very good fit, with a serial correlation (SC) of .31, to the recovery data. The maximum difference between calculated and actual recovery data is 1.3%. However, using the n thus calculated from the recovery data, it provided only a poor fit to the creep data, with a serial correlation of .91 and a maximum difference between calculated and actual curves of 4.2%. The poor fit of the creep data is a result of both a less than optimum value of n and a slightly erratic creep curve.

The Cend Modification

The constitutive equation for recovery goes to zero at long times. However, most of the recovery tests run and the literature seem to indicate that not all of the creep will be recovered after the load is removed. Specifically, some permanent, or plastic, deformation has occurred during the creep test and this will result in a recovery curve that will approach a minimum value during recovery equal to the amount of plastic deformation that occurred during creep.

To reflect this it was proposed that the recovery equation be modified as follows

$$\epsilon_r = C_0[(1 + a_\sigma \lambda)^n - (a_\sigma \lambda)^n] + C_{end} \quad (52)$$

where C_{end} is a parameter that contains all of the nonrecoverable portion of the creep. When this equation was set up on the computer it was found to provide a much better fit to the data than equation (41). This results both from the more realistic formulation of the equation and from simply adding the extra degree of freedom provided by C_{end} .

Equation (52) is able to fit a broader range of data. It was found that the equation would fit the data within a certain range even if one of the parameters in the equation, such as n , was fixed. In other words, if the value of one of the parameters in the equation was already solved, within a certain range, the computer would adjust the remaining three parameters to attain a good fit to the data. This allowed a new method to be used to solve the creep and recovery data. First the creep data, rather than the recovery data, is solved to determine ϵ_0 , C' and n . This provides a good fit to the data since the computer is able to solve for an optimum value of n . The value of n calculated is then used in the solution of the modified recovery equation.

Sample Calculation with C_{end}

Using the BMDP3R program to solve the creep data for equation (44)

$$\epsilon_0 = 2.1642 \times 10^{-3} \pm 0.0157 \times 10^{-3}$$

$$C' = 0.0632 \times 10^{-3} \pm 0.00707 \times 10^{-3}$$

$$n = 0.5329 \pm 0.0202$$

Using the n calculated above and the BMDP3R program to solve the recovery data for equation (52)

$$C_0 = 0.72368 \times 10^{-3}$$

$$a_\sigma = 0.76123$$

$$C_{end} = 0.18626$$

Then, as before

$$\Delta \epsilon_1 = .0632 \times 10^{-3} (119.80)^{.5329}$$

$$\Delta \epsilon_1 = .80970 \times 10^{-3}$$

$$g_1 = .80970 \times 10^{-3} / .72368 \times 10^{-3}$$

$$g_1 = 1.1189$$

$$g_0 = 2.1642 \times 10^{-3} \times 11.07 \times 10^6 / 23400$$

$$g_0 = 1.0238$$

$$C_1 g_2 = \frac{(0.0632 \times 10^{-3})(0.76123)^{.5329}}{(23400)(1.1189)}$$

$$C_1 g_2 = 2.0873 \times 10^{-9}$$

Table 1 is a comparison of all of the calculated values.

Note that the values calculated from the three methods are somewhat different. The values calculated from the computer using the outlined method compare fairly well with those calculated by curve shifting and are certainly within the limits of error of the curve shifting results. g_0 and g_1 are both close to 1, this is to be expected since this is a low stress test and these parameters basically reflect nonlinearities in the elastic responses of the material. In higher stress creep tests in metals these would be expected to increase slightly with stress.

In the constitutive equation a_σ is an indication of how fast the recovery curve approaches zero, the slower it approaches zero the lower is a_σ . a_σ in the constitutive equation would be close to 1 at very low stress where all of the creep, if any, is quickly recoverable; as the stress increased it would approach zero. In the equation with C_{end} much of the function of a_σ has been taken over by C_{end} and hence a_σ is much closer to 1. Since C_{end} reflects the amount of plastic creep taking place, a_σ now reflects how rapidly the recovery curve approaches the value of plastic strain. C_{end} will increase with increasing stress, however it is not clear what effect increasing stress will have on a_σ .

Table 1. Comparison of Results for the Different Solution Methods

Parameter	Calculation Method		
	Graphical Curve-Shift	Computer	Cend
n	0.25	0.23696	0.5329
ϵ_0	1.821×10^{-3}	1.7072×10^{-3}	2.1642×10^{-3}
c_0	1.05×10^{-3}	1.053×10^{-3}	0.7236×10^{-3}
c'	0.3321×10^{-3}	0.3932×10^{-3}	0.0632×10^{-3}
g_0	0.86147	0.80761	1.0238
g_1	1.045	1.1601	1.1189
$c_1 g_2$	6.671×10^{-9}	7.210×10^{-9}	2.0873×10^{-9}
a_σ	0.0588	0.0526	0.7612
Cend	-	-	0.36498×10^{-3}
SC-Creep	-	.91255	.36498
Max % error - Creep	2.8	4.2	1.2
SC-Recovery	-	.31042	.16953
Max % error - recovery	1.8	1.3	1.4

Figures 5 and 6 indicate the fit of the calculated curves to the data. Notice that the Cend equation fits the data much better than the other equations. The SC in Table 1 stands for serial correlation; this is an indication of the quality of fit of the calculated values to the data values. Anything below about .4 is a very good fit, between .4 and .6 is good, between .6 and .75 is fair and above .75 is poor. Note that the Cend equation indicated a very good fit to both creep and recovery.

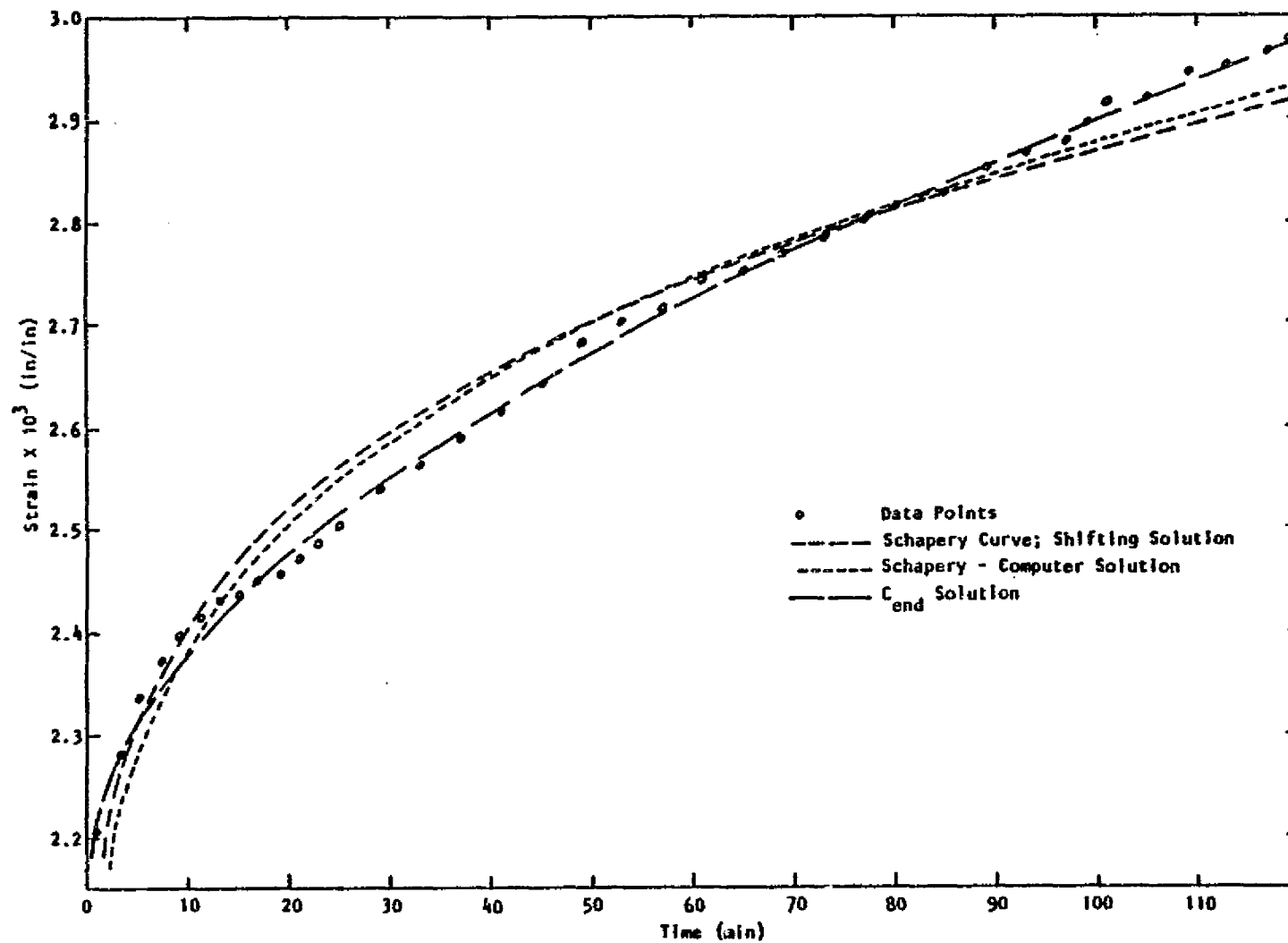


Figure 5. Creep data and equation solutions vs time for Ti-3 test

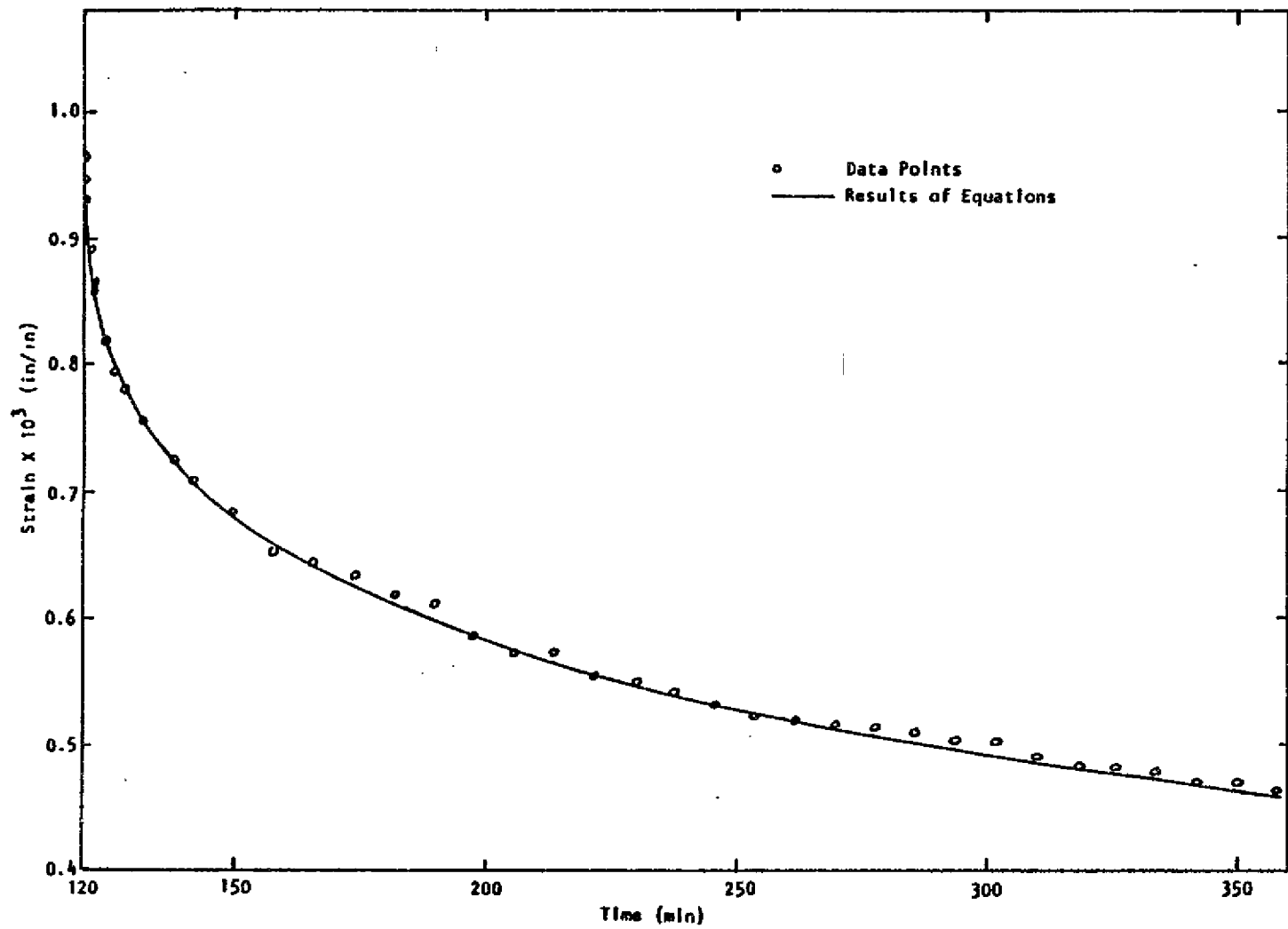


Figure 6. Recovery data and equation solutions vs time for Ti-3 test

EXPERIMENTAL PROCEDURE

Materials and Specimen Preparation

The materials selected for study in this work were: commercially pure 1100 aluminum, titanium, and Armco EMI iron along with 2024-T4 aluminum alloy and Ti-6Al-4V titanium alloy. All of these materials were obtained from commercial vendors.

Round specimens were used for creep testing. In all cases the gage lengths were two inches and the gage diameters 0.375 inches. Tolerance on the diameters was ± 0.001 inches.

The commercially pure metals were annealed so as to achieve a uniform grain size, and to remove the surface effects of machining. All heat treatments were done in a dynamic atmosphere of helium in order to reduce contamination effects.

The titanium alloy was heat treated at 815°C for one hour and slowly cooled. The aluminum alloy was heat treated at 340°C for 10 minutes and slowly cooled. For each of the alloys, the treatments noted were adequate to anneal out the surface cold work. The chemical compositions of the titanium and aluminum alloys are as follows:

	C	Fe	N	Al	Va	H	O	Ti
Ti-6Al-4V	0.01	0.04	0.009	6.45	4.25	0.005	0.184	Balance
	Cu	Mn	Mg	Al	Impurities			
2024-T4	4.4	0.6	1.5	Balance	Negligible Quantities			

Testing Procedures*

The basic procedure for all the tests consisted of subjecting a specimen to a predetermined constant load at a constant temperature. The load was transmitted through a lever arm (20:1 or 3:1 ratio) to the specimen by a mechanical linkage. An extensometer was fastened to the gage length of the specimen. Gage length deflection was transmitted through the extensometer to a linear variable differential transformer (LVDT). The signal from the LVDT was transmitted to a signal conditioner and finally to a recorder. A suppression circuit was designed such that full-

* Details of the components used in the creep test system are given in Appendix D.

scale travel of the pen could be suppressed a total of ten times, effectively expanding the useful scale of the chart by a factor of ten.

The LVDT transducer was calibrated through the use of a series of standard gage blocks with dimensions known to a tolerance of ± 0.00008 in. Through these known gage block displacements, a calibration curve for the LVDT system was constructed.

For the elevated temperature tests, the specimen-extensometer assembly was placed inside a temperature controlled electric furnace (most such tests were conducted in the range 185°C to 1150°C). To assure that the specimen was at the desired temperature, a thermocouple was attached to the gage length thus allowing a temperature measurement independent of that given by the furnace thermocouple. Temperature at the gage length was monitored on a digital display through a conditioner channel.

Since thermal transients are present in any high-temperature test, the system was allowed to stabilize at the desired temperature before any load was applied. Corrections were made for thermal expansions of the specimen and extensometer.

Application of the load was accomplished by transferring a predetermined amount of lead shot from a holding container to a loading container. The flow of shot from one container to another was an excellent method of loading because it allowed the load to be applied at a known rate that was easily reproducible from test to test. Further, since the loading rate could be so effectively controlled, impact effects were eliminated. By simply reversing the transfer process, controlled and reproducible unloading rates were accomplished for the relaxation tests. The transfer of the lead shot between containers was accomplished by gravity feed through openings of known area. Calibrations of the flow characteristics of the lead shot through these openings were carried out.

Temperature and Stress Ranges

The ranges of stress and temperature for creep tests on a particular material were predicated on obtaining significant amounts of primary creep during loading and reasonable amounts of time-dependent relaxation (not instantaneous) during unloading. These requirements necessitated considerable amounts of preliminary testing on each material. Generally, stress levels no greater than 0.6 of the yield stress, and temperatures signif-

icantly below the hot working range of the material were finally selected as the upper limits. Specific stresses and temperatures for a particular material are given in the results section of this report.

TEST RESULTS AND ANALYSIS

Commercially Pure Titanium, Aluminum, and Iron

The commercially pure metals did not give test results which exhibited consistent and uniform trends when subjected to analyses for determinations of the parameters in the basic constitutive equation. Accordingly, detailed data reductions were not done on these materials. The raw strain-time data for creep and relaxation are given on pages 31 through 64. In many cases, most especially the Armco EMI iron, there was great difficulty in obtaining significant time-dependent relaxation at stress levels where primary creep was not obliterated by the rapid onset of secondary (or even tertiary) creep. Because of these difficulties, and the attendant time constraints of the project, work on these materials was de-emphasized. A few parameter determinations were done on the 1100 aluminum and the titanium. The results of these determinations are given in Tables 2 and 3. There were not sufficient recovery data on the iron to allow a meaningful analysis on that material.

Index of Strain-Time Data for Commercially Pure Metals

<u>Titanium</u>			<u>Aluminum</u>		
<u>Temp (°C)</u>	<u>Stress (MPa)</u>	<u>Page</u>	<u>Temp (°C)</u>	<u>Stress (MPa)</u>	<u>Page</u>
Rm. Temp	227	31	Rm. Temp	13.9	44
Rm. Temp	234	32	Rm. Temp	17.4	45
Rm. Temp	248	33	Rm. Temp	20.7	46
Rm. Temp	262	34	Rm. Temp	22.4	47
Rm. Temp	276	35	Rm. Temp	24.1	48
306	69	36	Rm. Temp	24.1	49
306	83	37	185	8.3	50
306	110	38	185	11.0	51
306	110	39	185	13.8	52
422	44	40	185	16.5	53
422	44	41	231	7.4	54
422	55	42	231	9.3	55
422	66	43	231	9.3	56
			231	12.1	57
			231	12.1	58
			231	14.5	59
<u>Iron</u>					
<u>Temp (°C)</u>	<u>Stress (MPa)</u>	<u>Page</u>			
Rm. Temp	110	60			
Rm. Temp	53.8	62			
Rm. Temp	53.8	63			
318	48.3	61			
318	36.2	64			

TEST T-1
C.P. TITANIUM
ROOM TEMPERATURE
227 MPA (33,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0021110	0.	0.0000491
0.05	0.0021311	0.15	0.0000453
0.15	0.0021445	0.65	0.0000446
0.25	0.0021615	1.65	0.0000442
0.65	0.0021720	3.65	0.0000431
1.65	0.0021943	5.65	0.0000427
2.65	0.0022076	9.65	0.0000427
3.65	0.0022180	13.65	0.0000424
4.65	0.0022277	17.65	0.0000424
5.65	0.0022351	22.00	0.0000424
6.65	0.0022403	26.00	0.0000424
7.65	0.0022463	30.00	0.0000424
8.65	0.0022522	34.00	0.0000424
9.65	0.0022582	38.01	0.0000424
10.65	0.0022634	41.99	0.0000424
11.65	0.0022667	45.98	0.0000424
12.65	0.0022701	49.96	0.0000424
13.65	0.0022716	53.94	0.0000424
14.65	0.0022734	57.93	0.0000424
15.65	0.0022760	61.91	0.0000424
16.65	0.0022801	65.90	0.0000424
18.65	0.0022872	69.88	0.0000424
20.65	0.0022931	73.87	0.0000424
22.65	0.0022998	77.65	0.0000424
24.65	0.0023054	82.14	0.0000424
26.65	0.0023102	86.13	0.0000424
28.65	0.0023147	90.11	0.0000424
30.65	0.0023199	94.10	0.0000424

TEST T-2
C.P. TITANIUM
ROOM TEMPERATURE
234.4 MPA (34,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0019730	0.	0.0000861
0.23	0.0020035	0.05	0.0000698
0.43	0.0020116	0.12	0.0000694
1.40	0.0020295	1.10	0.0000687
2.40	0.0020391	3.10	0.0000676
3.40	0.0020458	5.10	0.0000668
4.40	0.0020510	9.10	0.0000665
5.40	0.0020562	13.10	0.0000663
6.40	0.0020599	17.10	0.0000661
7.40	0.0020651	21.10	0.0000657
8.40	0.0020681	25.10	0.0000654
9.40	0.0020718	29.10	0.0000654
10.40	0.0020740	33.10	0.0000653
11.40	0.0020785	36.10	0.0000650
12.40	0.0020822	39.10	0.0000646
13.40	0.0020852	42.10	0.0000639
14.40	0.0020889	45.10	0.0000635
15.40	0.0020918	48.10	0.0000631
16.40	0.0020955	51.10	0.0000627
17.40	0.0020993	54.10	0.0000627
18.40	0.0021022	57.10	0.0000627
19.40	0.0021052	63.00	0.0000627
20.40	0.0021082	69.00	0.0000627
22.40	0.0021126	75.00	0.0000627
24.40	0.0021178	81.00	0.0000627
26.40	0.0021230	87.00	0.0000627
28.40	0.0021282	93.00	0.0000627
30.40	0.0021319		

TEST T-3
C.P. TITANIUM
ROOM TEMPERATURE
248.2 MPA (36,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0028106	0.	0.0009841
0.03	0.0028479	0.50	0.0009751
1.00	0.0029717	1.00	0.0009722
2.00	0.0030149	2.00	0.0009699
3.00	0.0030425	4.00	0.0009677
4.00	0.0030671	6.00	0.0009658
5.00	0.0030872	10.00	0.0009640
6.00	0.0031051	14.00	0.0009628
7.00	0.0031200	18.00	0.0009621
8.00	0.0031342	22.00	0.0009614
9.00	0.0031491	26.00	0.0009610
10.00	0.0031618	30.00	0.0009602
11.00	0.0031745	34.00	0.0009599
12.00	0.0031864	38.00	0.0009595
13.00	0.0031991	42.00	0.0009591
14.00	0.0032095	46.00	0.0009587
15.00	0.0032207	50.00	0.0009584
16.00	0.0032319	54.00	0.0009580
17.00	0.0032423	58.00	0.0009576
18.00	0.0032520	62.00	0.0009573
19.00	0.0032617	66.00	0.0009565
20.00	0.0032699	70.00	0.0009565
22.00	0.0032885	74.00	0.0009563
24.00	0.0033057	78.00	0.0009563
26.00	0.0033221	82.00	0.0009561
28.00	0.0033381	86.00	0.0009561
30.00	0.0033541	90.00	0.0009558
		94.00	0.0009558

TEST T-4
C.P. TITANIUM
ROOM TEMPERATURE
262.0 MPA (38,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0030104	0.	0.0000572
0.05	0.0030156	1.00	0.0000513
1.00	0.0030587	2.00	0.0000491
2.00	0.0030825	4.00	0.0000468
3.00	0.0031011	8.00	0.0000453
4.00	0.0031160	12.00	0.0000439
5.00	0.0031308	16.00	0.0000435
6.00	0.0031420	20.00	0.0000431
7.00	0.0031539	24.00	0.0000427
8.00	0.0031628	28.00	0.0000427
9.00	0.0031754	32.00	0.0000427
10.00	0.0031836	36.00	0.0000427
11.00	0.0031925	40.00	0.0000427
12.00	0.0032022	44.00	0.0000424
13.00	0.0032113	48.00	0.0000424
14.00	0.0032200	52.00	0.0000424
15.00	0.0032297	56.00	0.0000424
16.00	0.0032379	60.00	0.0000424
17.00	0.0032475	64.00	0.0000422
18.00	0.0032550	68.00	0.0000421
19.00	0.0032631	72.00	0.0000416
20.00	0.0032713	76.00	0.0000401
22.00	0.0032884	80.00	0.0000394
24.00	0.0033055	84.00	0.0000387
26.00	0.0033226	88.00	0.0000387
28.00	0.0033397	92.00	0.0000385
30.00	0.0033560	96.00	0.0000384
31.00	0.0033627	100.00	0.0000379

TEST T-5
C.P. TITANIUM
ROOM TEMPERATURE
275.8 MPA (40,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0028810	0.	0.0014710
0.05	0.0029280	0.50	0.0014590
0.10	0.0030050	1.00	0.0014540
1.10	0.0031520	2.00	0.0014510
2.10	0.0032350	4.00	0.0014480
3.10	0.0032870	6.00	0.0014460
4.10	0.0033450	8.00	0.0014450
5.10	0.0033930	10.00	0.0014440
6.10	0.0034270	14.00	0.0014380
7.10	0.0034760	18.00	0.0014370
8.10	0.0034990	22.00	0.0014370
9.10	0.0035320	26.00	0.0014360
10.10	0.0035660	30.00	0.0014360
11.10	0.0035920	34.00	0.0014360
12.10	0.0036220	38.00	0.0014360
13.10	0.0036520	42.00	0.0014330
14.10	0.0036760	46.00	0.0014330
15.10	0.0036970	50.00	0.0014330
16.10	0.0037260	60.00	0.0014330
18.10	0.0037740	70.00	0.0014330
20.10	0.0038180	80.00	0.0014330
22.10	0.0038610	90.00	0.0014330
24.10	0.0039060		
26.10	0.0039460		
28.10	0.0039760		
30.10	0.0040100		

TEST T-6
C.P. TITANIUM
306 DEG. CELCIUS
69.0 MPA (10,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0007841	0.	0.0000761
0.50	0.0007925	1.00	0.0000723
1.00	0.0008001	2.00	0.0000716
2.00	0.0008123	3.00	0.0000693
3.00	0.0008183	4.00	0.0000678
4.00	0.0008267	5.00	0.0000670
5.00	0.0008343	6.00	0.0000655
6.00	0.0008389	7.00	0.0000647
8.00	0.0008450	8.00	0.0000647
10.00	0.0008450	10.00	0.0000624
12.00	0.0008450	12.00	0.0000617
14.00	0.0008452	16.00	0.0000612
16.00	0.0008452	20.00	0.0000612
18.00	0.0008455	30.00	0.0000612
20.00	0.0008455	39.99	0.0000612
22.00	0.0008457	50.02	0.0000612
24.00	0.0008457	59.80	0.0000612
26.00	0.0008457	70.20	0.0000612
28.00	0.0008457	80.08	0.0000612
30.00	0.0008457	89.96	0.0000612
32.00	0.0008457	99.84	0.0000612
34.00	0.0008457	110.24	0.0000612
36.00	0.0008457	120.12	0.0000612
40.00	0.0008457	130.00	0.0000612
42.00	0.0008457	139.88	0.0000612
44.00	0.0008457	149.76	0.0000612
48.00	0.0008457	160.16	0.0000612
52.00	0.0008457	170.04	0.0000612

TEST T-7
C.P. TITANIUM
306 DEG. CELCIUS
82.7 MPA (12,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0009259	0.	0.0000796
0.05	0.0009346	1.00	0.0000723
0.10	0.0009476	2.00	0.0000723
1.10	0.0009766	3.00	0.0000709
2.10	0.0009954	4.00	0.0000709
3.10	0.0010090	6.00	0.0000709
4.10	0.0010210	8.00	0.0000709
5.10	0.0010310	10.00	0.0000709
6.10	0.0010340	20.00	0.0000709
8.10	0.0010520	30.00	0.0000709
10.00	0.0010550	40.01	0.0000709
12.00	0.0010560	50.00	0.0000709
14.00	0.0010590	59.99	0.0000709
16.00	0.0010610	69.98	0.0000709
18.00	0.0010640	79.92	0.0000709
20.00	0.0010660	90.18	0.0000709
22.00	0.0010660	99.90	0.0000709
24.00	0.0010660	110.16	0.0000709
26.00	0.0010680	119.83	0.0000709
28.00	0.0010690	130.14	0.0000709
30.00	0.0010740	139.86	0.0000709
32.00	0.0010750	150.12	0.0000709
34.00	0.0010750	159.84	0.0000709
38.00	0.0010770	170.10	0.0000709
42.00	0.0010770	179.82	0.0000709
46.00	0.0010780		
50.00	0.0010780		
54.00	0.0010780		

TEST T-8
C.P. TITANIUM
306 DEG. CELCIUS
110.3 MPA (16,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0012310	0.	0.0020940
0.05	0.0016460	0.05	0.0020820
0.10	0.0017590	0.10	0.0020800
0.15	0.0018320	0.20	0.0020790
0.25	0.0019280	0.33	0.0020790
0.35	0.0019380	1.33	0.0020780
0.85	0.0021020	2.30	0.0020780
1.85	0.0022220	3.33	0.0020770
2.85	0.0023020	5.33	0.0020770
3.85	0.0023580	7.30	0.0020770
4.85	0.0023950	10.00	0.0020770
5.85	0.0024240	20.00	0.0020770
6.85	0.0024480	30.00	0.0020770
8.85	0.0024830	39.99	0.0020770
10.85	0.0025110	50.02	0.0020770
14.85	0.0025440	59.80	0.0020770
18.85	0.0025650	70.20	0.0020770
22.85	0.0025810	80.08	0.0020770
26.85	0.0025940	89.96	0.0020770
30.85	0.0026020	99.84	0.0020770
34.85	0.0026070	110.24	0.0020770
38.85	0.0026100	120.12	0.0020770
42.85	0.0026130	130.00	0.0020770
46.85	0.0026180	139.88	0.0020770
50.85	0.0026240	149.76	0.0020770
52.00	0.0026260	160.16	0.0020770
		170.04	0.0020770

TEST T-9
C.P. TITANIUM
306 DEG. CELCIUS
110.3 MPA (16,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
C.	0.0011052	0.	0.0018992
0.25	0.0013204	0.50	0.0018916
0.50	0.0013960	1.00	0.0018904
0.75	0.0014832	1.50	0.0018888
1.00	0.0016238	2.50	0.0018876
2.00	0.0017448	3.50	0.0018856
3.00	0.0018120	4.00	0.0018852
4.00	0.0018556	5.00	0.0018852
6.00	0.0019252	6.00	0.0018852
8.00	0.0019776	7.00	0.0018352
10.00	0.0020300	8.00	0.0018852
15.00	0.0021288	10.00	0.0018348
20.00	0.0022148	12.00	0.0018844
25.00	0.0022844	14.00	0.0018344
30.00	0.0023352	16.00	0.0018844
35.00	0.0023672	18.00	0.0018844
40.00	0.0023876	20.00	0.0018844
45.00	0.0024000	22.00	0.0018840
50.00	0.0024080	24.00	0.0018836
55.00	0.0024172	26.00	0.0018836
60.00	0.0024228	28.00	0.0018836
65.00	0.0024288	30.00	0.0018820
70.00	0.0024348	32.00	0.0018816
75.00	0.0024376	34.00	0.0018816
80.00	0.0024420		
85.00	0.0024472		
90.00	0.0024496		
95.00	0.0024516		
100.00	0.0024576		

TEST T-10
C.P. TITANIUM
422 DEG. CELCIUS
44.1 MPA (6,400 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
C.	0.0005780		
0.05	0.0005930		
1.00	0.0006060		
2.00	0.0006170		
3.00	0.0006250		
4.00	0.0006310		
5.00	0.0006320		
6.00	0.0006340		
7.00	0.0006350		
8.00	0.0006350		
9.00	0.0006350		
10.00	0.0006370		
12.00	0.0006440		
14.00	0.0006450		
16.00	0.0006510		
18.00	0.0006530		
20.00	0.0006550		
24.00	0.0006610		
28.00	0.0006640		
32.00	0.0006720		
36.00	0.0006740		
40.00	0.0006770		
44.00	0.0006770		
48.00	0.0006770		
52.00	0.0006790		
56.00	0.0006830		
60.00	0.0006830		
62.00	0.0006840		

TEST T-11
C.P. TITANIUM
422 DEG. CELCIUS
44.1 MPA (6,400 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0004784	0.	0.0002721
0.02	0.0004835	2.00	0.0002502
0.05	0.0004905	4.00	0.0002380
0.10	0.0004941	6.00	0.0002290
1.00	0.0005303	8.00	0.0002259
2.00	0.0005472	12.00	0.0002181
4.00	0.0005785	16.00	0.0002135
6.00	0.0005837	20.00	0.0002120
8.00	0.0005935	24.00	0.0002111
10.00	0.0006004	28.00	0.0002095
12.00	0.0006044	32.00	0.0002093
14.00	0.0006044	36.00	0.0002093
16.00	0.0006069	40.00	0.0002093
18.00	0.0006131	50.00	0.0002092
20.00	0.0006148	60.00	0.0002092
22.00	0.0006172	70.00	0.0002092
26.00	0.0006208	80.00	0.0002086
30.00	0.0006244	90.00	0.0002083
34.00	0.0006291	100.00	0.0002077
38.00	0.0006342	110.00	0.0002064
42.00	0.0006393	120.00	0.0001945
46.00	0.0006462	130.00	0.0001945
50.00	0.0006486	140.00	0.0001924
54.00	0.0006551	150.00	0.0001922
58.00	0.0006607	160.00	0.0001917
62.00	0.0006646	170.00	0.0001917
64.00	0.0006684	180.00	0.0001899
		184.00	0.0001899

TEST T-12
C.P. TITANIUM
422 DEG. CELCIUS
55.2 MPA (8,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0006832	0.	0.0001708
0.02	0.0006873	0.05	0.0001670
0.05	0.0006894	0.10	0.0001667
0.10	0.0006914	0.15	0.0001664
1.00	0.0007150	1.00	0.0001449
2.00	0.0007265	2.00	0.0001334
4.00	0.0007503	3.00	0.0001319
6.00	0.0007636	4.00	0.0001252
8.00	0.0007759	8.00	0.0001169
10.00	0.0007830	12.00	0.0001165
12.00	0.0007877	16.00	0.0001163
14.00	0.0007904	20.00	0.0001160
16.00	0.0007907	30.00	0.0001095
18.00	0.0007924	40.00	0.0001025
20.00	0.0007963	50.00	0.0000963
24.00	0.0008045	60.00	0.0000931
28.00	0.0008104	70.00	0.0000886
32.00	0.0008207	80.00	0.0000827
36.00	0.0008328	90.00	0.0000819
40.00	0.0008440	100.00	0.0000804
44.00	0.0008493	110.00	0.0000801
48.00	0.0008510	120.00	0.0000739
52.00	0.0008543	130.00	0.0000686
56.00	0.0008596	140.00	0.0000651
60.00	0.0008657	150.00	0.0000651
64.00	0.0008690	160.00	0.0000651
68.00	0.0008690	170.00	0.0000651
		180.00	0.0000651
		205.00	0.0000651

TEST T-13
C.P. TITANIUM
422 DEG. CELCIUS
66.2 MPA (9,600 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0010130	0.	0.0005034
0.02	0.0010200	0.05	0.0004899
0.05	0.0010250	0.10	0.0004890
0.08	0.0010290	0.13	0.0004882
1.00	0.0010370	2.10	0.0004319
2.00	0.0011240	4.10	0.0004116
3.00	0.0011480	6.10	0.0003973
6.00	0.0011910	8.10	0.0003887
8.00	0.0012140	12.10	0.0003756
10.00	0.0012300	16.10	0.0003687
12.00	0.0012480	20.10	0.0003607
14.00	0.0012580	24.10	0.0003518
16.00	0.0012700	28.10	0.0003514
18.00	0.0012840	30.00	0.0003506
20.00	0.0012890	40.00	0.0003398
22.00	0.0012970	50.00	0.0003318
24.00	0.0013080	60.00	0.0003300
26.00	0.0013160	70.00	0.0003243
28.00	0.0013250	80.00	0.0003202
30.00	0.0013330	90.00	0.0003172
34.00	0.0013440	100.00	0.0003074
38.00	0.0013610	110.00	0.0003071
42.00	0.0013680	120.00	0.0003070
46.00	0.0013810	130.00	0.0003068
50.00	0.0013850	140.00	0.0002981
54.00	0.0013920	150.00	0.0002969
58.00	0.0014070	160.00	0.0002925
		170.00	0.0002916
		180.00	0.0002904

TEST A-1
1100 ALUMINUM
ROOM TEMPERATURE
13.9 MPA (2020 PSI)

OFFICE ELECTRONICS INC. #1

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0001893	0.	0.0000218
0.05	0.0001925	0.05	0.0000134
0.15	0.0001940	0.15	0.0000128
1.15	0.0001954	1.15	0.0000117
2.15	0.0001966	2.15	0.0000093
3.15	0.0001972	3.15	0.0000090
4.15	0.0001981	4.15	0.0000085
5.15	0.0001981	5.15	0.0000076
6.15	0.0001982	6.15	0.0000073
7.15	0.0001982	8.00	0.0000073
8.15	0.0001982	10.00	0.0000073
9.15	0.0001982	12.00	0.0000073
10.15	0.0001982	14.00	0.0000073
11.15	0.0001982	18.00	0.0000073
12.00	0.0001982	22.00	0.0000073
13.00	0.0001982	26.00	0.0000073
14.00	0.0001982	30.00	0.0000073
15.00	0.0001982	35.00	0.0000073
16.00	0.0001982	40.00	0.0000073
17.00	0.0001982	45.00	0.0000073
18.00	0.0001982	50.00	0.0000073
19.00	0.0001982	55.00	0.0000073
20.00	0.0001982	60.00	0.0000073

TEST A-2
 1100 ALUMINUM
 ROOM TEMPERATURE
 17.4 MPA (2525 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0002796	0.	0.0000437
0.05	0.0002904	0.05	0.0000291
0.15	0.0002913	0.15	0.0000288
1.00	0.0002942	1.00	0.0000283
2.00	0.0002942	2.00	0.0000288
3.00	0.0002943	4.00	0.0000288
4.00	0.0002948	10.00	0.0000288
5.00	0.0002948	15.00	0.0000288
6.00	0.0002950	20.00	0.0000288
7.00	0.0002950	25.00	0.0000283
8.00	0.0002950	30.00	0.0000288
10.00	0.0002956	35.00	0.0000288
14.00	0.0002956	40.00	0.0000288
18.00	0.0002956	45.00	0.0000288
22.00	0.0002956	50.00	0.0000288
26.00	0.0002956	55.00	0.0000288
30.00	0.0002956	60.00	0.0000288
		65.00	0.0000288
		70.00	0.0000288
		75.00	0.0000288
		80.00	0.0000288
		90.00	0.0000288

TEST A-3
1100 ALUMINUM
ROOM TEMPERATURE
20.1 MPa (3000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0002895	0.	0.0000979
0.03	0.0002979	0.02	0.0000970
0.50	0.0003090	0.05	0.0000961
1.00	0.0003107	1.00	0.0000952
1.50	0.0003122	2.00	0.0000949
2.00	0.0003128	6.00	0.0000946
4.00	0.0003149	10.00	0.0000943
6.00	0.0003167	14.00	0.0000943
8.00	0.0003176	18.00	0.0000940
10.00	0.0003188	22.00	0.0000901
12.00	0.0003194	26.00	0.0000899
14.00	0.0003200	30.00	0.0000899
16.00	0.0003212	34.00	0.0000899
0.18	0.0003218	38.00	0.0000899
20.00	0.0003224	42.00	0.0000899
22.00	0.0003227	46.00	0.0000899
24.00	0.0003230	50.00	0.0000899
26.00	0.0003231	54.00	0.0000899
28.00	0.0003236	58.00	0.0000899
30.00	0.0003236	62.00	0.0000899
		66.00	0.0000899
		70.00	0.0000899
		74.00	0.0000899
		78.00	0.0000899
		82.00	0.0000898
		86.00	0.0000898
		90.00	0.0000897

TEST A-4
1100 ALUMINUM
ROOM TEMPERATURE
22.4 MPA (3250 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0004098	0.	0.0002731
0.05	0.0004273	0.05	0.0002705
0.10	0.0004308	0.80	0.0002676
1.10	0.0004403	1.80	0.0002668
2.10	0.0004422	3.80	0.0002662
3.10	0.0004436	5.80	0.0002658
4.10	0.0004446	9.80	0.0002655
6.10	0.0004460	14.00	0.0002652
8.10	0.0004472	18.00	0.0002651
10.10	0.0004483	22.00	0.0002650
12.10	0.0004488	26.00	0.0002650
14.10	0.0004495	30.00	0.0002648
16.10	0.0004502	34.00	0.0002647
18.10	0.0004509	38.00	0.0002647
20.10	0.0004510	42.00	0.0002646
22.10	0.0004512	46.00	0.0002645
24.10	0.0004516	50.00	0.0002643
26.10	0.0004523	54.00	0.0002642
28.10	0.0004524	58.00	0.0002640
30.10	0.0004526	62.00	0.0002639
32.10	0.0004528	66.00	0.0002638
34.10	0.0004529	70.00	0.0002638
36.10	0.0004530	80.00	0.0002636
38.10	0.0004533	90.00	0.0002634
40.10	0.0004535	100.00	0.0002634
42.10	0.0004538	110.00	0.0002634
		120.00	0.0002634
		130.00	0.0002634

TEST A-5
 1100 ALUMINUM
 ROOM TEMPERATURE
 24.1 MPA (3500 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0002940	0.	0.0001060
0.02	0.0002960	1.00	0.0001050
1.00	0.0003060	2.00	0.0001050
2.00	0.0003080	3.00	0.0001050
3.00	0.0003100	4.00	0.0001040
4.00	0.0003120	5.00	0.0001040
5.00	0.0003140	6.00	0.0001040
6.00	0.0003150	7.00	0.0001040
7.00	0.0003160	8.00	0.0000970
8.00	0.0003170	10.00	0.0000970
9.00	0.0003170	12.00	0.0000970
10.00	0.0003180	14.00	0.0000970
12.00	0.0003190	16.00	0.0000970
14.00	0.0003200	18.00	0.0000970
16.00	0.0003200		
18.00	0.0003210		
20.00	0.0003220		
22.00	0.0003220		
24.00	0.0003230		
26.00	0.0003230		
28.00	0.0003230		
30.00	0.0003240		

TEST A-6
1100 ALUMINUM
ROOM TEMPERATURE
24.1 MPA (3500 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0004096	0.	0.0002710
0.50	0.0004310	0.03	0.0002680
1.00	0.0004330	0.50	0.0002660
2.00	0.0004350	1.00	0.0002660
3.00	0.0004370	2.00	0.0002650
4.00	0.0004380	3.00	0.0002650
5.00	0.0004390	4.00	0.0002650
6.00	0.0004390	5.00	0.0002650
7.00	0.0004400	9.00	0.0002650
8.00	0.0004400	13.00	0.0002650
9.00	0.0004410	17.00	0.0002650
10.00	0.0004410	21.00	0.0002650
12.00	0.0004420	25.00	0.0002650
14.00	0.0004420	35.00	0.0002640
16.00	0.0004430	45.00	0.0002640
18.00	0.0004430	55.00	0.0002640
20.00	0.0004440	65.00	0.0002640
22.00	0.0004440	75.00	0.0002640
24.00	0.0004440	85.00	0.0002640
26.00	0.0004440	95.00	0.0002630
28.00	0.0004450	105.00	0.0002630
30.00	0.0004450	115.00	0.0002630
32.00	0.0004450	125.00	0.0002630
36.00	0.0004450	135.00	0.0002630
38.00	0.0004460	145.00	0.0002630
40.00	0.0004460		

TEST A-7
1100 ALUMINUM
185 DEG. CELCIUS
8.3 MPA (1200 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0001910	0.	0.0000380
0.05	0.0002020	0.05	0.0000380
0.10	0.0002060	0.15	0.0000370
0.20	0.0002110	1.10	0.0000340
0.70	0.0002190	2.10	0.0000340
1.20	0.0002230	3.10	0.0000340
2.10	0.0002250	4.10	0.0000340
3.10	0.0002260	5.10	0.0000340
4.10	0.0002260	6.10	0.0000340
5.10	0.0002260	7.10	0.0000340
6.10	0.0002260	8.00	0.0000340
8.10	0.0002260	10.00	0.0000340
10.10	0.0002260	12.00	0.0000340
12.10	0.0002260	14.00	0.0000340
14.00	0.0002260	20.00	0.0000340
16.00	0.0002260		
18.00	0.0002260		

TEST A-3
1100 ALUMINUM
185 DEG. CELCIUS
11.0 MPA (1600 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0001893	0.	0.0001037
0.45	0.0001986	0.05	0.0001008
1.45	0.0002045	0.10	0.0000996
2.45	0.0002100	1.00	0.0000947
3.45	0.0002155	2.00	0.0000891
4.45	0.0002173	3.00	0.0000862
5.45	0.0002205	4.00	0.0000853
6.45	0.0002240	5.00	0.0000824
8.45	0.0002298	6.00	0.0000818
10.45	0.0002342	8.00	0.0000801
12.45	0.0002391	10.00	0.0000775
14.45	0.0002420	12.00	0.0000775
16.45	0.0002471	16.00	0.0000757
18.45	0.0002502	20.00	0.0000716
20.45	0.0002511	24.00	0.0000708
22.45	0.0002537	28.00	0.0000708
24.45	0.0002554	32.00	0.0000690
26.45	0.0002578	36.00	0.0000676
28.45	0.0002598	40.00	0.0000675
30.45	0.0002627	50.00	0.0000674
32.45	0.0002642	60.00	0.0000674
34.45	0.0002682	70.00	0.0000674
36.45	0.0002709	79.99	0.0000674
38.45	0.0002738	89.98	0.0000674
40.45	0.0002746	99.98	0.0000674
42.45	0.0002813	110.02	0.0000674
43.45	0.0002815	120.01	0.0000674
		130.00	0.0000674
		140.00	0.0000674

JEL

TEST A-9
 1100 ALUMINUM
 185 DEG. CELCIUS
 13.8 MPA (2000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0003004	0.	0.0001229
0.05	0.0003062	0.03	0.0001200
0.10	0.0003117	0.07	0.0001199
1.00	0.0003436	1.00	0.0001163
2.00	0.0003520	2.00	0.0001134
3.00	0.0003546	3.00	0.0001128
4.00	0.0003575	4.00	0.0001127
5.00	0.0003592	6.00	0.0001127
6.00	0.0003618	8.00	0.0001127
8.00	0.0003674	10.00	0.0001127
10.00	0.0003679	14.00	0.0001119
12.00	0.0003734	18.00	0.0001119
14.00	0.0003755	22.00	0.0001119
16.00	0.0003772	26.00	0.0001119
18.00	0.0003824	30.00	0.0001119
20.00	0.0003862	34.00	0.0001119
22.00	0.0003865	38.00	0.0001119
24.00	0.0003865	42.00	0.0001119
26.00	0.0003866	46.00	0.0001119
28.00	0.0003879	50.00	0.0001119
30.00	0.0003888	50.00	0.0001119
32.00	0.0003891	70.00	0.0001119
34.00	0.0003891	90.00	0.0001119
36.00	0.0003891	90.00	0.0001119
38.00	0.0003891	100.00	0.0001119
40.00	0.0003891	110.00	0.0001119
		120.00	0.0001119
		130.00	0.0001119

OFFICE ELECTRONICS INC. #1

TEST A-10
1100 ALUMINUM
135 DEG. CELCIUS
16.5 MPA (2400 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
C.	0.0003476	0.	0.0002548
C.02	0.0003568	0.05	0.0002519
C.05	0.0003613	1.00	0.0002476
1.00	0.0003925	2.00	0.0002428
2.00	0.0004062	3.00	0.0002422
3.00	0.0004178	4.00	0.0002379
4.00	0.0004257	5.00	0.0002376
6.00	0.0004368	7.00	0.0002348
8.00	0.0004436	8.00	0.0002348
10.00	0.0004509	10.00	0.0002312
12.00	0.0004620	14.00	0.0002310
14.00	0.0004593	18.00	0.0002309
16.00	0.0004642	22.00	0.0002309
18.00	0.0004687	26.00	0.0002308
20.00	0.0004761	30.00	0.0002284
24.00	0.0004835	40.00	0.0002281
28.00	0.0004899	50.00	0.0002251
32.00	0.0004994	60.00	0.0002251
36.00	0.0005057	70.00	0.0002251
40.00	0.0005131	80.00	0.0002251
44.00	0.0005190	90.00	0.0002251
48.00	0.0005227	100.00	0.0002251
52.00	0.0005239	110.00	0.0002251
56.00	0.0005264	120.00	0.0002251
60.00	0.0005273	130.00	0.0002251
		140.00	0.0002251
		160.00	0.0002251
		180.00	0.0002251

TEST A-11
 1100 ALUMINUM
 231 DEG. CELCIUS
 7.4 MPA (1080 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0001200	0.	0.0000710
0.10	0.0001270	0.05	0.0000700
0.60	0.0001380	0.10	0.0000690
1.10	0.0001440	1.10	0.0000690
2.10	0.0001480	2.10	0.0000690
3.10	0.0001510	3.00	0.0000690
4.10	0.0001530	4.00	0.0000690
5.10	0.0001530	6.00	0.0000690
6.10	0.0001530	8.00	0.0000690
7.10	0.0001540	10.00	0.0000690
8.10	0.0001580	12.00	0.0000690
9.10	0.0001590	14.00	0.0000690
10.10	0.0001610	16.00	0.0000690
12.10	0.0001630	18.00	0.0000690
14.00	0.0001670		
16.00	0.0001720		
18.00	0.0001750		
20.00	0.0001820		
22.00	0.0001820		
24.00	0.0001820		
28.00	0.0001820		

TEST A-12
1100 ALUMINUM
231 DEG. CELCIUS
9.3 MPa (1350 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
C.	0.0001158	0.	0.0005279
C.03	0.0001279	0.10	0.0005059
C.10	0.0001404	0.15	0.0004995
C.15	0.0001462	0.17	0.0004978
C.20	0.0001482	1.16	0.0004489
C.50	0.0001574	2.16	0.0004254
1.50	0.0001831	3.16	0.0004107
2.50	0.0002169	4.16	0.0003997
3.50	0.0002460	5.16	0.0003887
4.50	0.0002642	10.16	0.0003652
5.50	0.0002796	20.16	0.0003386
6.50	0.0002964	30.16	0.0003239
C.50	0.0003487	40.16	0.0003175
14.50	0.0003959	50.16	0.0003088
18.50	0.0004338	60.16	0.0003021
22.50	0.0004648	70.16	0.0002969
26.50	0.0004923	80.16	0.0002958
30.50	0.0005169	90.00	0.0002958
35.50	0.0005455	100.00	0.0002958
40.50	0.0005751	120.00	0.0002958
45.50	0.0006008	140.00	0.0002958
50.50	0.0006231	160.00	0.0002958
55.50	0.0006465	180.00	0.0002958
60.50	0.0006665	200.00	0.0002958
65.50	0.0006833	220.00	0.0002958
70.50	0.0007021	240.00	0.0002958
75.50	0.0007172	260.00	0.0002958
80.50	0.0007389		
84.50	0.0007542		

TEST A-13
1100 ALUMINUM
231 DEG. CELCIUS
9.3 MPA (1350 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0002073	0.	0.0006790
0.02	0.0002164	0.05	0.0006623
0.05	0.0002255	0.10	0.0006530
0.10	0.0002395	0.15	0.0006451
0.15	0.0002497	0.25	0.0006346
0.30	0.0002760	1.25	0.0005870
0.80	0.0003358	3.25	0.0005446
1.30	0.0003831	5.25	0.0005257
3.30	0.0004424	10.25	0.0005035
5.80	0.0004833	15.25	0.0004848
8.80	0.0005257	20.25	0.0004763
11.80	0.0005651	25.25	0.0004696
15.80	0.0006121	30.25	0.0004600
18.80	0.0006422	40.25	0.0004541
21.80	0.0006682	50.25	0.0004538
24.80	0.0006936	60.25	0.0004526
27.80	0.0007155	70.25	0.0004524
30.80	0.0007415	80.00	0.0004524
33.80	0.0007634	90.00	0.0004524
36.80	0.0007856	100.00	0.0004524
39.80	0.0008083	110.00	0.0004524
42.80	0.0008270	120.00	0.0004524
45.80	0.0008457	130.00	0.0004524
48.80	0.0008629	140.00	0.0004524
51.80	0.0008790	150.00	0.0004524
54.80	0.0008951	160.00	0.0004524
57.80	0.0009068	170.00	0.0004524
		180.00	0.0004524

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TEST A-14
1100 ALUMINUM
231 DEG. CELCIUS
12.1 MPA (1750 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0001249	0.	0.0001559
0.02	0.0001272	0.02	0.0001545
0.05	0.0001288	0.05	0.0000541
0.10	0.0001296	1.00	0.0000521
1.10	0.0001357	2.00	0.0000520
2.10	0.0001411	4.00	0.0000520
3.10	0.0001427	6.00	0.0000520
4.10	0.0001453	8.00	0.0000520
5.10	0.0001464	10.00	0.0000520
6.10	0.0001482	14.00	0.0000520
8.10	0.0001546	18.00	0.0000520
10.10	0.0001561	22.00	0.0000520
12.10	0.0001590	26.00	0.0000520
14.10	0.0001618	30.00	0.0000520
16.10	0.0001651	34.00	0.0000507
20.10	0.0001718	40.00	0.0000507
24.10	0.0001789	50.00	0.0000494
28.10	0.0001830	60.00	0.0000494
32.10	0.0001876	70.00	0.0000494
36.10	0.0001905	80.00	0.0000494
40.10	0.0001948	90.00	0.0000494
44.10	0.0001990	99.98	0.0000494
48.10	0.0002007	109.98	0.0000494
52.10	0.0002044	119.98	0.0000494
56.10	0.0002079	129.98	0.0000494
60.10	0.0002106	139.97	0.0000494
62.10	0.0002114	159.97	0.0000494
		180.03	0.0000494
		186.30	0.0000494

TEST A-15
1100 ALUMINUM
231 DEG. CELCIUS
12.1 MPA (1750 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0002021	0.	0.0000377
0.03	0.0002057	0.05	0.0000856
0.05	0.0002062	0.10	0.0000843
0.07	0.0002063	1.10	0.0000838
1.00	0.0002122	2.10	0.0000802
2.00	0.0002126	3.10	0.0000785
3.00	0.0002146	4.10	0.0000773
4.00	0.0002162	6.10	0.0000756
5.00	0.0002164	8.10	0.0000743
6.00	0.0002164	10.10	0.0000736
8.00	0.0002184	14.10	0.0000731
10.00	0.0002198	20.10	0.0000730
12.00	0.0002199	25.00	0.0000730
16.00	0.0002199	30.00	0.0000715
20.00	0.0002217	40.00	0.0000713
24.00	0.0002226	50.00	0.0000710
28.00	0.0002248	60.00	0.0000710
32.00	0.0002318	70.00	0.0000684
36.00	0.0002355	80.00	0.0000676
40.00	0.0002370	90.00	0.0000661
44.00	0.0002400	100.00	0.0000654
48.00	0.0002436	110.00	0.0000654
52.00	0.0002462	120.00	0.0000654
56.00	0.0002496	130.00	0.0000654
60.00	0.0002543	150.00	0.0000654
64.00	0.0002579	160.00	0.0000654
		170.00	0.0000654
		180.00	0.0000654

TEST A-16
1100 ALUMINUM
231 DEG. CELCIUS
14.5 MPA (2100 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0001627	0.	0.0002478
0.05	0.0001694	0.02	0.0002426
1.00	0.0002002	0.05	0.0002420
2.00	0.0002206	0.10	0.0002417
3.00	0.0002327	1.10	0.0002404
4.00	0.0002416	2.10	0.0002392
5.00	0.0002502	3.10	0.0002385
6.00	0.0002573	4.10	0.0002381
8.00	0.0002727	5.10	0.0002380
10.00	0.0002843	6.10	0.0002380
12.00	0.0002928	10.00	0.0002380
14.00	0.0003005	14.00	0.0002380
16.00	0.0003076	18.00	0.0002377
18.00	0.0003173	20.00	0.0002377
20.00	0.0003235	30.00	0.0002377
22.00	0.0003303	40.00	0.0002377
24.00	0.0003392	50.00	0.0002377
26.00	0.0003475	60.00	0.0002377
28.00	0.0003538	70.00	0.0002377
30.00	0.0003578	80.00	0.0002377
34.00	0.0003700	90.00	0.0002377
38.00	0.0003819	100.00	0.0002377
42.00	0.0003859	110.00	0.0002377
46.00	0.0003936	120.00	0.0002377
50.00	0.0004022	130.00	0.0002377
54.00	0.0004111	140.00	0.0002377
58.00	0.0004147	160.00	0.0002377
62.00	0.0004177	180.00	0.0002377
		200.00	0.0002377

TEST I-1
 ARMCO IRON
 ROOM TEMPERATURE
 110.3 MPA (16,000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0016980	0.	0.0002548
0.05	0.0017450	5.00	0.0002548
0.10	0.0017720	10.00	0.0002548
0.15	0.0017910	15.00	0.0002548
0.65	0.0018490	20.00	0.0002548
1.15	0.0018750	30.00	0.0002548
2.15	0.0019000		
3.15	0.0019190		
4.10	0.0019220		
5.10	0.0019300		
6.10	0.0019370		
7.10	0.0019420		
8.10	0.0019470		
9.10	0.0019510		
10.10	0.0019550		
11.10	0.0019670		
12.10	0.0019650		
13.10	0.0019670		
14.10	0.0019670		
15.10	0.0019690		
16.10	0.0019720		
17.10	0.0019720		
18.00	0.0019740		
20.00	0.0019800		
21.00	0.0019800		
22.00	0.0019820		
23.00	0.0019830		

TEST I-2
 ARMCO IRON
 318 DEG. CELCIUS
 48.3 MPA (7000 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0003730	0.	0.0002460
0.50	0.0003800	1.00	0.0002390
1.00	0.0003810	2.00	0.0002340
2.00	0.0003850	4.00	0.0002340
3.00	0.0003860	6.00	0.0002290
4.00	0.0003860	8.00	0.0002280
5.00	0.0003870	10.00	0.0002230
6.00	0.0003870	18.00	0.0002230
8.00	0.0003930	22.00	0.0002200
10.00	0.0003930	26.00	0.0002190
12.00	0.0003960	30.00	0.0002180
14.00	0.0003960	38.00	0.0002180
16.00	0.0003970	46.00	0.0002170
18.00	0.0003980	50.00	0.0002170
20.00	0.0003980	58.00	0.0002150
24.00	0.0004000	64.00	0.0002140
28.00	0.0004040	80.00	0.0002140
32.00	0.0004050	100.00	0.0002140
36.00	0.0004060	120.00	0.0002140
40.00	0.0004080	140.00	0.0002130
44.00	0.0004090	160.00	0.0002140
46.00	0.0004130	180.00	0.0002140
48.00	0.0004170		
50.00	0.0004210		
52.00	0.0004250		
53.00	0.0004250		

TEST I-3
 ARMCO IRON
 ROOM TEMPERATURE
 53.8 MPA (7800 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0002760	0.	0.0000105
0.05	0.0002810	0.02	0.0000050
1.05	0.0002820	0.05	0.0000030
2.05	0.0002820	0.10	0.0000018
3.05	0.0002830	1.00	0.
7.05	0.0002840	2.00	0.
11.00	0.0002850	4.00	0.
15.00	0.0002850	6.00	0.
19.00	0.0002850	8.00	0.
23.00	0.0002850	10.00	0.
27.00	0.0002850	15.00	0.
31.00	0.0002850	20.00	0.
35.00	0.0002850	25.00	0.
39.00	0.0002850	30.00	0.
43.00	0.0002850	35.00	0.
47.00	0.0002850	40.00	0.
51.00	0.0002860		
55.00	0.0002860		
59.00	0.0002860		
63.00	0.0002860		

TEST I-4
 ARMCO IRON
 ROOM TEMPERATURE
 53.8 MPA (7800 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0004920	0.	0.0003480
0.05	0.0005150	0.05	0.0003470
0.10	0.0005240	0.10	0.0003460
0.20	0.0005310	1.10	0.0003460
0.70	0.0005480	2.10	0.0003450
1.20	0.0005570	3.10	0.0003450
2.20	0.0005660	5.00	0.0003450
4.20	0.0005760	10.00	0.0003450
6.20	0.0005830	15.00	0.0003450
8.20	0.0005900	20.00	0.0003450
10.20	0.0005920	25.00	0.0003450
12.20	0.0005960	30.00	0.0003450
16.20	0.0006010	40.00	0.0003450
20.20	0.0006060	50.00	0.0003450
22.20	0.0006080	60.00	0.0003450
24.20	0.0006100	70.00	0.0003450
26.20	0.0006110	72.00	0.0003450
28.20	0.0006130		
30.20	0.0006140		
34.20	0.0006220		
38.20	0.0006300		
42.20	0.0006350		
46.20	0.0006390		
50.00	0.0006420		
54.00	0.0006450		
58.25	0.0006480		

TEST I-5
 ARMO IRON
 318 DEG. CELCIUS
 36.2 MPA (5250 PSI)

CREEP		RECOVERY	
TIME (MIN)	STRAIN	TIME (MIN)	STRAIN
0.	0.0005610	0.	0.0004760
0.05	0.0005680	0.10	0.0004750
1.00	0.0005780	1.10	0.0004720
2.00	0.0005830	2.10	0.0004710
3.00	0.0005920	3.10	0.0004690
4.00	0.0005880	4.10	0.0004690
5.00	0.0005900	5.10	0.0004690
6.00	0.0005940	6.10	0.0004670
8.00	0.0006010	8.10	0.0004620
10.00	0.0006050	10.10	0.0004610
12.00	0.0006100	14.10	0.0004610
14.00	0.0006110	18.10	0.0004610
16.00	0.0006120	22.00	0.0004610
18.00	0.0006130	26.00	0.0004610
20.00	0.0006130	30.00	0.0004610
24.00	0.0006130	34.00	0.0004610
28.00	0.0006130	40.00	0.0004600
32.00	0.0006140	50.00	0.0004600
36.00	0.0006140	60.00	0.0004600
40.00	0.0006140		
44.00	0.0006140		
48.00	0.0006150		
52.00	0.0006150		
56.00	0.0006150		
62.00	0.0006150		

Table 2. Parameters for Commercially Pure Aluminum and Titanium

	Temperature (°C)	Stress (MPa)	t_a (min)	ϵ_o (10 ⁻³)	C' (10 ⁻³)	n	C_o (10 ⁻³)	a_σ	C_{end} (10 ⁻³)
Aluminum									
	Room Temp.	13.9	20	0.160	0.0358	0.0265	0.0563	2.3119	0.0068
	Room Temp.	17.4	30	0.2793	0.0140	0.0560	0.0096	1000.0	0.0288
	Room Temp.	20.7	36	0.2938	0.0183	0.1409	0.0192	0.6122	0.0822
	Room Temp.	22.4	42.1	0.4103	0.0283	0.1198	0.0123	0.4565	0.2626
	185	11.0	43.45	0.1882	0.0145	0.4855	0.0453	4.6647	0.0601
	185	13.8	40.0	0.2393	0.1000	0.1174	0.0216	13.7472	0.1117
	185	16.5	60.0	0.3406	0.0539	0.3095	0.0383	3.2441	0.2216
	231	9.3	84.5	0.1327	0.0695	0.4955	0.2730	12.8642	0.2665
	231	12.1	62.1	0.1245	0.0100	0.5253	0.0071	0.7263	0.0467
	231	21.4	62.0	0.1501	0.0533	0.3968	0.0064	52.1268	0.2374
Titanium									
	Room Temp.	227	30.65	2.097	0.0844	0.2801	0.0058	10.8964	0.0422
	Room Temp.	248	30.0	2.8158	0.1464	0.3788	0.0291	0.8616	0.9506
	Room Temp.	262	31.0	3.0184	0.0389	0.6299	0.0191	1.5903	0.0333
	306	68.9	52.0	0.7117	0.1000	0.0888	0.0911	10.8668	0.0604
	306	82.7	54.0	0.8298	0.1598	0.1230	0.0410	200.0	0.0708
	306	110	52.0	1.2897	0.8068	0.1443	0.0227	274.7290	2.0770
	422	44.1	64.0	0.4265	0.1105	0.1808	0.1208	0.8814	0.1858
	422	55.2	68.0	0.6734	0.0459	0.3471	0.1565	0.2417	0.0134
	422	66.2	58.0	0.9743	0.1257	0.3059	0.2622	0.8913	0.2598

Table 3. Parameters for Commercially Pure Aluminum and Titanium

	<u>Temperature (°C)</u>	<u>Stress (MPa)</u>	<u>A(o) (10⁻⁸)</u>	<u>C₁ (10⁻⁸)</u>	<u>g₀</u>	<u>g₁</u>	<u>g₂</u>
Aluminum							
	Room Temp.	13.9	7.9208	2.6316	1.0	0.6885	1.0
	Room Temp.	17.4			1.3963	1.7702	0.1755
	Room Temp.	20.7			1.2365	1.5459	0.0807
	Room Temp.	22.4			1.5939	3.5987	0.0836
	185	11.0	11.7617	0.9590	1.0	1.9992	1.0
	185	13.8			1.0175	7.1311	0.9946
	185	16.5			1.2068	4.9987	0.6749
	231	9.3	9.8316	7.9576	1.0	2.2956	1.0
	231	12.1			0.7234	12.2692	0.005
	231	21.4			0.4926	43.1463	0.0241
Titanium							
	Room Temp.	227	6.3557	0.0132	1.0	37.7955	1.0
	Room Temp.	248			1.2307	18.2368	1.5958
	Room Temp.	262			1.2498	17.7530	0.5851
	306	68.9	7.1174	0.7929	1.0	1.5588	1.0
	306	82.7			0.97	6.3650	0.5062
	306	110			1.1325	6.2926	2.2731
	422	44.1	6.6642	0.8698	1.0	1.9399	1.0
	422	55.2			1.2630	1.2678	0.3176
	422	66.2			1.5229	1.6602	0.8755

2024-T4 Aluminum Alloy

The aluminum alloy was tested at stress levels in the range 0.5 to 0.7 of the yield stress and at temperatures between 255°C and 275°C. The ranges of stress and temperature are shown schematically in Figure 7. The raw strain-time data for creep and relaxation are given on pages 70 through 93. It should be noted that these data (as well as the data for the titanium alloy) are preceded by an index to the individual tests, along with an explanation of the computer tabulations and plots of the data.

When subjected to analysis, this material exhibited reproducible results that were reasonably predictable from the constitutive equation. Table 4 shows the computer generated constants for particular conditions of temperature, stress, and time that would be necessary to establish the basic creep and recovery equations. Table 5 shows the internal parameters calculated for each of the above test conditions. Graphs of all the parameters as functions of stress and temperature are given in Figures 8 through 10. The curves demonstrate that in the 2024 aluminum alloy, the parameters vary in a reasonably regular way in the stress and temperature ranges studied.

Index of Strain-Time Data for 2024-T4 Aluminum Alloy

<u>Temp (°C)</u>	<u>Stress (MPa)</u>	<u>%σ_y</u>	<u>Page</u>
225	103	0.5	70
225	124	0.6	72
225	139	0.65	74
225	144	0.7	76
250	91	0.5	78
250	109	0.6	80
250	118	0.65	82
250	127	0.7	84
275	71	0.5	86
275	85	0.6	88
275	92	0.65	90
275	100	0.7	92

Each test is represented by a page of tabulated data and a page with the data plotted. In the tabulations, the upper set represents creep and the lower set relaxation. Time values are in minutes, and all strains (predicted, observed, residual) should be multiplied by 10^{-3} .

The column listing "predicted strain" represents those values predicted by a constitutive equation with parameters based upon the raw data input. The fit of this equation to the input data is shown by the columns "residual" and "standard deviation of predicted value."

In the plots, the values of strain and time are shown vertically and horizontally respectively, in the lower portion of the printout.

The same format of data presentation applies to the titanium alloy which is discussed in the next section.

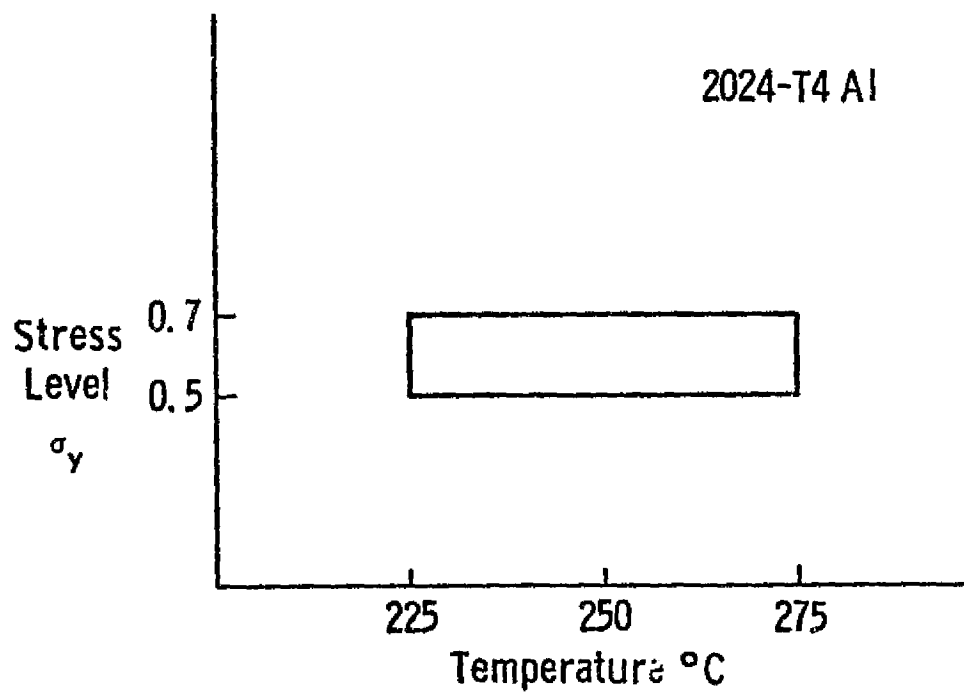


Figure 7. Stress and temperature ranges for creep testing of 2024-T4 aluminum alloy.

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.911347	1.011779	1.929700	0.118353	3.111000
2	1.951341	1.011115	1.977700	0.026359	6.011000
3	1.977100	1.011177	1.975250	-0.001850	9.011000
4	1.995000	1.011239	1.992700	-0.002300	12.011000
5	2.015400	1.011244	2.016770	0.001370	15.011000
6	2.030957	1.011144	2.021700	-0.009257	18.011000
7	2.040125	1.011173	2.030700	-0.009425	21.011000
8	2.050000	1.011163	2.040000	-0.010000	24.011000
9	2.060000	1.011154	2.050000	-0.010000	27.011000
10	2.070000	1.011157	2.060000	-0.010000	30.011000
11	2.080000	1.011161	2.070000	-0.010000	33.011000
12	2.090000	1.011165	2.080000	-0.010000	36.011000
13	2.100000	1.011171	2.090000	-0.010000	39.011000
14	2.110000	1.011172	2.100000	-0.010000	42.011000
15	2.120000	1.011172	2.110000	-0.010000	45.011000
16	2.130000	1.011172	2.120000	-0.010000	48.011000
17	2.140000	1.011172	2.130000	-0.010000	51.011000
18	2.150000	1.011172	2.140000	-0.010000	54.011000
19	2.160000	1.011172	2.150000	-0.010000	57.011000
20	2.170000	1.011172	2.160000	-0.010000	60.011000
21	2.180000	1.011172	2.170000	-0.010000	61.116700

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R(I) * R(I-1))}{\sqrt{(\sum (R(I)^2) * \sum (R(I-1)^2))}}$

SERIAL CORRELATION OF RESIDUALS ORDERED BY CASE NUMBER
0.792-5

AI 1

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	0.461309	0.00367	0.462290	0.000981	0.000820
2	0.465492	0.00247	0.461280	-0.004212	0.017180
3	0.461784	0.00185	0.461280	-0.000503	0.049920
4	0.467790	0.00161	0.461280	0.006510	0.066270
5	0.438877	0.00109	0.461280	0.022403	0.131720
6	0.438049	0.00091	0.461280	0.023231	0.197160
7	0.437573	0.00086	0.461280	0.023707	0.262610
8	0.437260	0.00086	0.461280	0.024020	0.328050
9	0.437036	0.00085	0.461280	0.024244	0.393510
10	0.435867	0.00090	0.461280	0.024413	0.458960
11	0.435736	0.00093	0.439180	0.002446	0.524410
12	0.435627	0.00095	0.437780	0.001153	0.589860
13	0.435538	0.00097	0.437780	0.001262	0.655300
14	0.435463	0.00099	0.437780	0.001317	0.720750
15	0.435398	0.00101	0.436280	-0.009118	0.786200
16	0.435342	0.00103	0.436280	-0.009202	0.851650
17	0.435293	0.00104	0.436280	-0.009283	0.917100
18	0.435250	0.00105	0.430770	-0.004520	0.982550
19	0.435212	0.00107	0.430770	-0.004542	1.048000
20	0.435177	0.00108	0.430770	-0.004507	1.113440

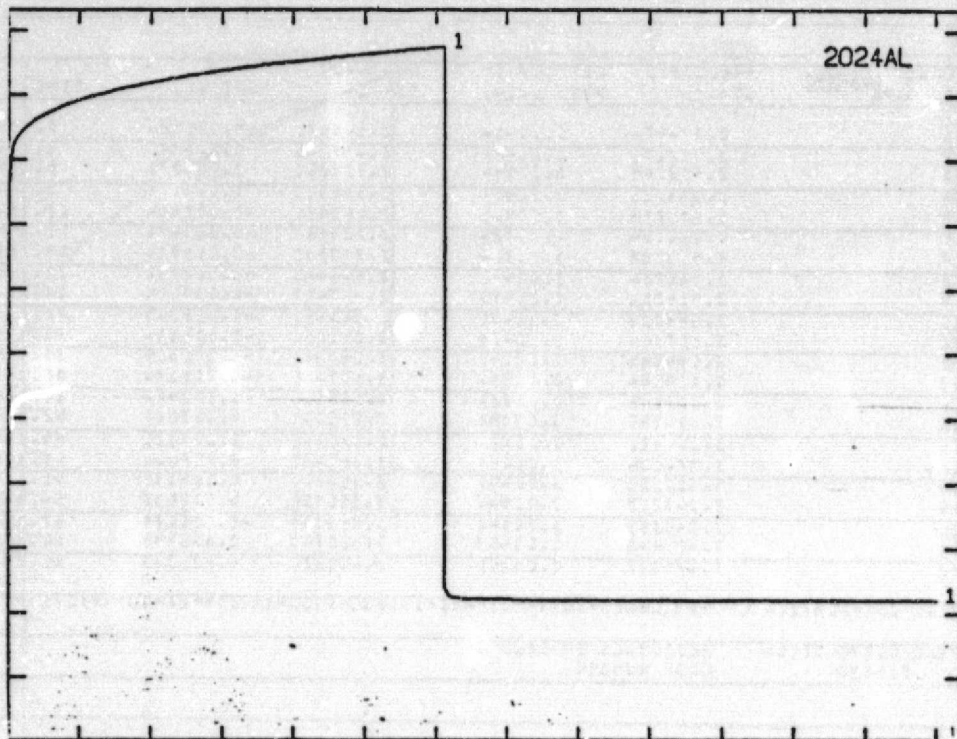
SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R(I) * R(I-1))}{\sqrt{(\sum (R(I)^2) * \sum (R(I-1)^2))}}$

SERIAL CORRELATION OF RESIDUALS ORDERED BY CASE NUMBER
0.79505

AI 1

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PLOT NUMBER									
2024AL ALLOY TEMP. 4225 C STRESS 50									
TIME BASE									
TOTAL TIME 110.0 MIN									
RECOVERY AT 01.1 MIN									
INCREMENT OF TIME 0.050 MIN									
INPUT VARIABLES									
LINE	STRESS	CO	CI	GO	GI	G2	EX	CEAO	TIME
NUMBER	(PSI)								
1	14940.7	41A7DA-240	21A11E-081	000000	915001	000000	262750	43547E-03	01.11073
0.220E-02									
0.250E-02									
0.120E-02									
0.140E-02									
0.140E-02									
0.120E-02									
0.100E-02									
0.800E-03									
0.800E-03									
0.600E-03									
0.200E-03									
0.200E-03									
0									
10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0
110.0	120.0	130.0							

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.174974	1.111111	2.111111	-0.124424	0.146733
2	2.174974	1.111111	2.111111	-0.124424	3.146733
3	2.174974	1.111111	2.111111	-0.124424	6.146733
4	2.174974	1.111111	2.111111	-0.124424	9.146733
5	2.174974	1.111111	2.111111	-0.124424	12.146733
6	2.174974	1.111111	2.111111	-0.124424	15.146733
7	2.174974	1.111111	2.111111	-0.124424	18.146733
8	2.174974	1.111111	2.111111	-0.124424	21.146733
9	2.174974	1.111111	2.111111	-0.124424	24.146733
10	2.174974	1.111111	2.111111	-0.124424	27.146733
11	2.174974	1.111111	2.111111	-0.124424	30.146733
12	2.174974	1.111111	2.111111	-0.124424	33.146733
13	2.174974	1.111111	2.111111	-0.124424	36.146733
14	2.174974	1.111111	2.111111	-0.124424	39.146733
15	2.174974	1.111111	2.111111	-0.124424	42.146733
16	2.174974	1.111111	2.111111	-0.124424	45.146733
17	2.174974	1.111111	2.111111	-0.124424	48.146733
18	2.174974	1.111111	2.111111	-0.124424	51.146733
19	2.174974	1.111111	2.111111	-0.124424	54.146733
20	2.174974	1.111111	2.111111	-0.124424	57.146733
21	2.174974	1.111111	2.111111	-0.124424	60.146733
22	2.174974	1.111111	2.111111	-0.124424	63.146733

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)*R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)*\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION 0.15584 RESIDUALS ORDERED ON CASE NUMBER

M 1

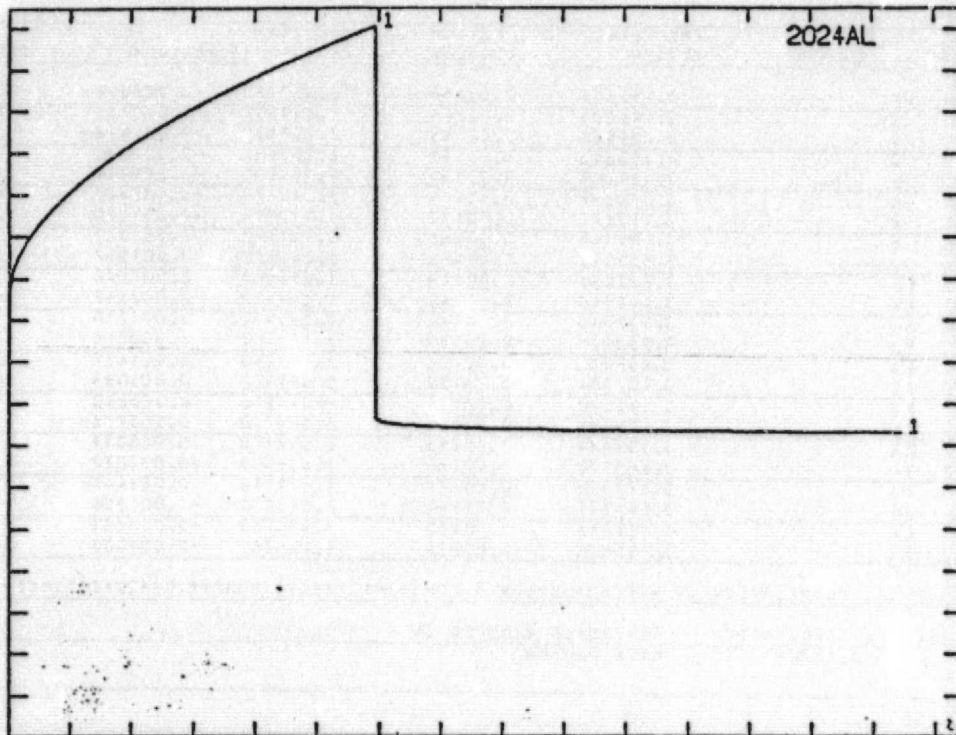
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.519330	0.00381	1.529630	0.010300	0.002770
2	1.509862	0.00245	1.500000	-0.009862	0.019350
3	1.498283	0.00190	1.483300	-0.009393	0.069120
4	1.492306	0.00188	1.487410	-0.002896	0.135170
5	1.485165	0.00179	1.485190	0.000025	0.201430
6	1.481409	0.00166	1.485190	0.003781	0.268130
7	1.478481	0.00151	1.481430	0.002949	0.334530
8	1.475104	0.00137	1.481430	0.005326	0.400890
9	1.471119	0.00125	1.477780	0.003661	0.467240
10	1.472420	0.00116	1.474070	0.001650	0.533590
11	1.470955	0.00109	1.474070	0.003115	0.599940
12	1.469662	0.00106	1.470370	0.000708	0.666300
13	1.468514	0.00106	1.470370	0.001856	0.732650
14	1.467484	0.00108	1.465670	-0.000814	0.799000
15	1.465553	0.00112	1.465570	0.000017	0.865360
16	1.465706	0.00118	1.466670	0.000964	0.931710
17	1.464931	0.00125	1.465670	0.000739	0.998060
18	1.464217	0.00132	1.462960	-0.001257	1.064420
19	1.462558	0.00140	1.462960	0.000402	1.130770
20	1.462946	0.00147	1.459260	-0.003686	1.197120
21	1.462376	0.00155	1.459260	-0.003114	1.263430
22	1.461843	0.00163	1.459260	-0.002583	1.329830
23	1.461343	0.00171	1.459260	-0.002083	1.396130

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)*R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)*\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION 0.29105 RESIDUALS ORDERED ON CASE NUMBER

M 2

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2024AL ALLOY TEMP. 4225 C STRESS 60										
PLOT NUMBER										
TIME BASE										
TOTAL TIME 144.5 MIN										
RECOVERY AT 39.5 MIN										
INCREMENT OF TIME 0.726 MIN										
INPUT VARIABLES										
LINE	STRESS	CO	CI	GO	GI	GO	GI	GO	GI	ENT
NUMBER	(PSI)									
1	17926.0.88730E-040.23613E-081.033004.5e0000.335170.557e80.14354e-02	60.26337	2.57726							
0.34CE-02										
0.32CE-02										
0.30CE-02										
0.28CE-02										
0.26CE-02										
0.24CE-02										
0.22CE-02										
0.20CE-02										
0.18CE-02										
0.16CE-02										
0.14CE-02										
0.12CE-02										
0.10CE-02										
0.08CE-02										
0.06CE-02										
0.04CE-02										
0.02CE-02										
0										
10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0
120.0	130.0	140.0	150.0							

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.455313	0.00456	2.452920	-0.002393	0.100000
2	2.546575	0.00241	2.557330	0.010755	1.100000
3	2.734533	0.00206	2.739100	0.004567	2.100000
4	2.350643	0.00191	2.343160	-0.007483	3.100000
5	2.934843	0.00189	2.924930	-0.009913	4.100000
6	3.052597	0.00184	3.025270	-0.027327	5.100000
7	3.112170	0.00177	3.110750	-0.001420	6.100000
8	3.179353	0.00168	3.131370	-0.047983	7.100000
9	3.239513	0.00156	3.240430	0.000917	8.100000
10	3.293235	0.00149	3.295520	0.002285	9.100000
11	3.342343	0.00140	3.344900	0.002557	10.100000
12	3.387740	0.00134	3.387490	-0.000250	11.100000
13	3.430075	0.00129	3.430330	0.000255	12.100000
14	3.469333	0.00126	3.471250	0.001917	13.100000
15	3.507334	0.00130	3.508420	0.001086	14.100000
16	3.545020	0.00135	3.549310	0.004290	15.100000
17	3.575974	0.00143	3.582760	0.006786	16.100000
18	3.609439	0.00153	3.612490	0.003051	17.100000
19	3.640572	0.00166	3.638530	-0.002042	18.100000
20	3.670506	0.00179	3.671950	0.001444	19.100000
21	3.699335	0.00194	3.696000	-0.003335	20.100000
22	3.727213	0.00210	3.723930	-0.003283	21.100000
23	3.755668	0.00226	3.746280	-0.009388	22.100000

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I))^2 - \sum(R(I-1))^2)}}$

SERIAL CORRELATION RESIDUALS ORDERED ON
U.43209 CASE NUMBER

A1 3

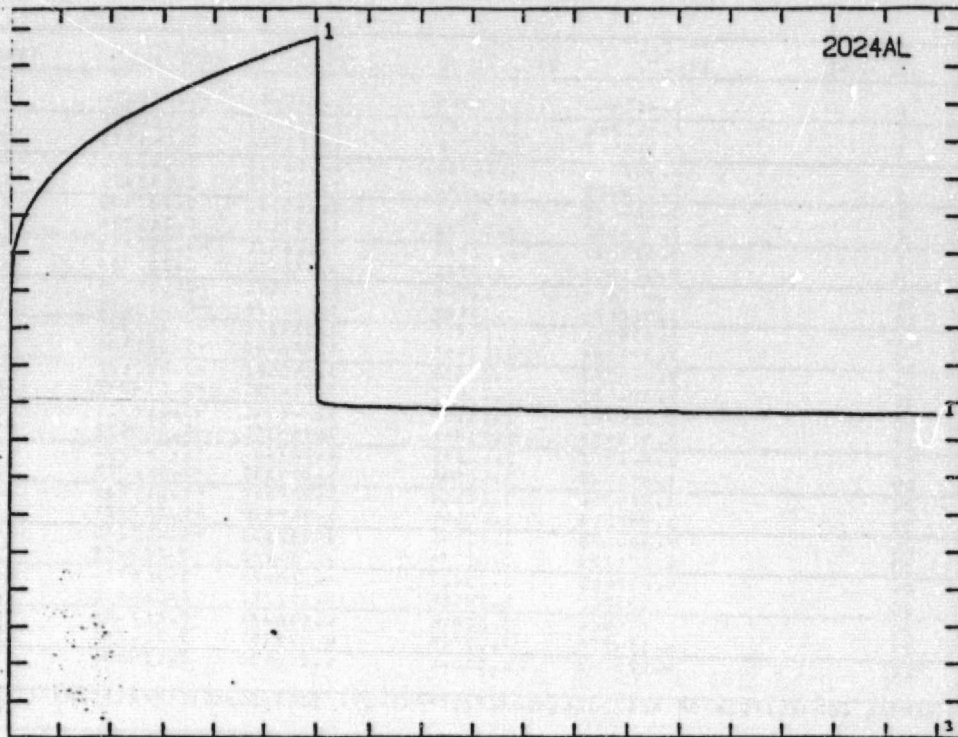
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.798996	0.00208	1.806240	0.007244	0.003320
2	1.791756	0.00172	1.786170	-0.005586	0.019910
3	1.788045	0.00154	1.782460	-0.005585	0.036500
4	1.785124	0.00142	1.780230	-0.004894	0.053090
5	1.778095	0.00112	1.775020	-0.003075	0.119460
6	1.771295	0.00091	1.772790	0.001495	0.219010
7	1.766414	0.00082	1.772790	0.006376	0.318570
8	1.762528	0.00078	1.769080	0.006552	0.418120
9	1.759271	0.00078	1.763130	0.003859	0.517670
10	1.756453	0.00079	1.760160	0.003707	0.617220
11	1.753962	0.00081	1.754210	0.000248	0.716770
12	1.751726	0.00084	1.754210	0.002484	0.816330
13	1.749695	0.00086	1.752730	0.003035	0.915880
14	1.747834	0.00089	1.746780	-0.001054	1.015430
15	1.746116	0.00091	1.746040	-0.000076	1.114930
16	1.744519	0.00093	1.744550	0.000031	1.214530
17	1.743028	0.00095	1.743060	0.000032	1.314090
18	1.741630	0.00097	1.739350	-0.002280	1.413640
19	1.740313	0.00099	1.737860	-0.002453	1.513190
20	1.739069	0.00101	1.737860	-0.001209	1.612740
21	1.737890	0.00102	1.737860	-0.000030	1.712290
22	1.736770	0.00103	1.733560	-0.003210	1.811850
23	1.735703	0.00104	1.733400	-0.002303	1.911400
24	1.735020	0.00105	1.731910	-0.003110	1.977770

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I))^2 - \sum(R(I-1))^2)}}$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.52292 CASE NUMBER

A1 3

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PLOT NUMBER
2024AL ALLOY TEMP. 225 C STRESS 65

TIME BASE
TOTAL TIME 179.9 MIN
RECOVERY AT 90.3 MIN
INCREMENT OF TIME 0.900 MIN

INPUT VARIABLES

LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	TIME	ENT
NUMBER	(PSI)												
1	19422.0	16290E-03	0.2511E-01	0.4500E-01	0.3000E-01	0.1010E-01	0.1710E-01	0.10019E-02	60.27000	0.11312			
0.320E-02													
0.340E-02													
0.360E-02													
0.380E-02													
0.400E-02													
0.420E-02													
0.440E-02													
0.460E-02													
0.480E-02													
0.500E-02													
0.520E-02													
0.540E-02													
0.560E-02													
0.580E-02													
0.600E-02													
0.620E-02													
0.640E-02													
0.660E-02													
0.680E-02													
0.700E-02													
0.720E-02													
0.740E-02													
0.760E-02													
0.780E-02													
0.800E-02													
0.820E-02													
0.840E-02													
0.860E-02													
0.880E-02													
0.900E-02													
0.920E-02													
0.940E-02													
0.960E-02													
0.980E-02													
1.000E-02													
1.020E-02													
1.040E-02													
1.060E-02													
1.080E-02													
1.100E-02													
1.120E-02													
1.140E-02													
1.160E-02													
1.180E-02													
1.200E-02													
1.220E-02													
1.240E-02													
1.260E-02													
1.280E-02													
1.300E-02													
1.320E-02													
1.340E-02													
1.360E-02													
1.380E-02													
1.400E-02													
1.420E-02													
1.440E-02													
1.460E-02													
1.480E-02													
1.500E-02													
1.520E-02													
1.540E-02													
1.560E-02													
1.580E-02													
1.600E-02													
1.620E-02													
1.640E-02													
1.660E-02													
1.680E-02													
1.700E-02													
1.720E-02													
1.740E-02													
1.760E-02													
1.780E-02													
1.800E-02													
1.820E-02													
1.840E-02													
1.860E-02													
1.880E-02													
1.900E-02													
1.920E-02													
1.940E-02													
1.960E-02													
1.980E-02													
2.000E-02													

CASE NO.	CASE NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1		3.011964	1.011969	2.735492	-0.275472	0.166700
2		2.913264	1.011974	2.914721	0.001457	1.166700
3		2.934567	1.011987	3.131500	0.196933	2.166700
4		3.112740	1.011917	3.153100	0.040360	4.166700
5		3.169325	1.011794	3.212400	0.043075	5.166700
6		3.124145	1.011745	3.245100	0.120955	6.166700
7		3.276180	1.011782	3.247100	-0.029080	7.166700
8		3.326743	1.011777	3.225500	-0.101243	8.166700
9		3.021912	1.011761	3.032770	0.010858	10.166700
10		3.057425	1.011745	3.044100	-0.011324	11.166700
11		3.512671	1.011724	3.040700	-0.471971	12.166700
12		3.536550	1.011715	3.536200	-0.000350	13.166700
13		3.594553	1.011682	3.576300	-0.021747	14.166700
14		3.693157	1.011635	3.662600	-0.030557	16.166700
15		3.720471	1.011615	3.704700	-0.018241	17.166700
16		3.764281	1.011597	3.745900	-0.018381	18.166700
17		3.813872	1.011587	3.745200	-0.068672	19.166700
18		3.842942	1.011585	3.827300	-0.015642	20.166700
19		3.841533	1.011593	3.859500	0.017967	21.166700
20		3.919586	1.011613	3.937800	0.018214	22.166700
21		3.957219	1.011644	3.949900	-0.007671	23.166700
22		3.994425	1.011545	3.992100	-0.002325	24.166700
23		4.031225	1.011734	4.034200	0.002975	25.166700
24		4.067646	1.011801	4.076400	0.008754	26.166700
25		4.113700	1.011869	4.118500	0.004800	27.166700
26		4.179404	1.011946	4.156800	-0.022604	28.166700
27		4.174775	1.011929	4.199300	0.024525	29.166700
28		4.179748	1.011941	4.226600	0.046852	29.300000

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot P(I-1))}{\sqrt{(\sum(R(I))^2) \cdot (\sum(P(I-1))^2)}}$

SERIAL CORRELATION 0.57550 RESIDUALS ORDERED ON CASE NUMBER

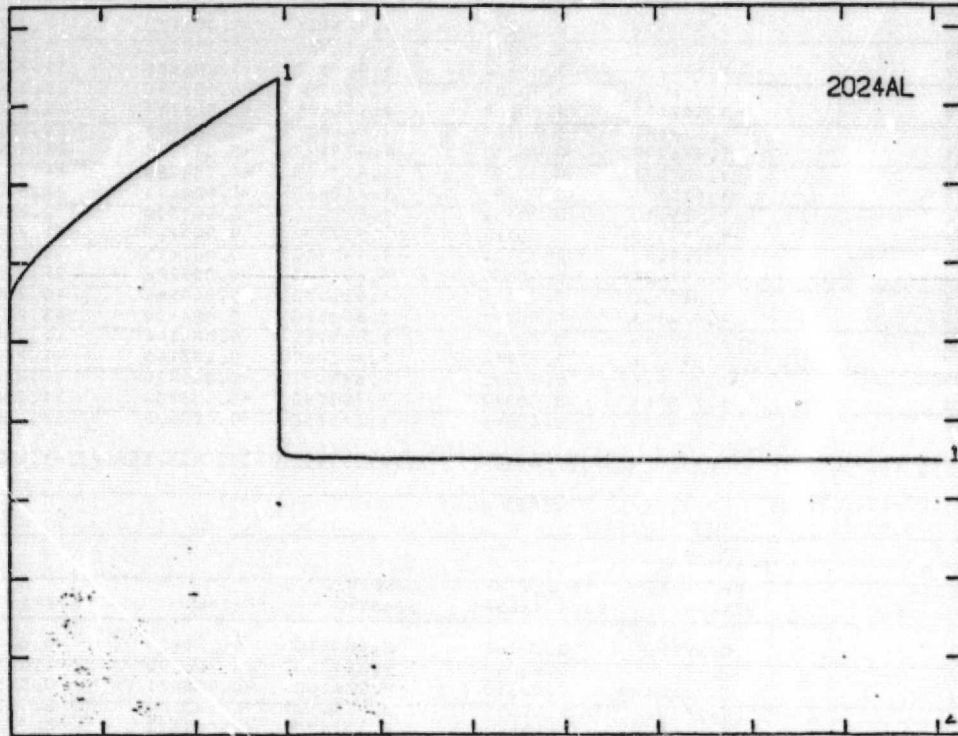
M 4

CASE NO.	CASE NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1		1.797711	0.00265	1.800670	0.002959	0.003990
2		1.774950	0.00143	1.770020	-0.004930	0.038100
3		1.765128	0.00098	1.758530	-0.006598	0.106340
4		1.758491	0.00077	1.758530	0.000039	0.242820
5		1.755391	0.00073	1.758530	0.003139	0.379300
6		1.753442	0.00073	1.758530	0.005088	0.515790
7		1.752050	0.00073	1.758530	0.006480	0.652270
8		1.751053	0.00074	1.754700	0.003647	0.778750
9		1.750125	0.00074	1.750870	0.000745	0.925230
10		1.749413	0.00077	1.750870	0.001457	1.061710
11		1.748807	0.00078	1.747040	-0.001767	1.198190
12		1.748281	0.00080	1.747040	-0.001243	1.334680
13		1.747822	0.00081	1.745500	-0.002322	1.471150
14		1.747412	0.00082	1.745500	-0.001912	1.607640
15		1.747044	0.00083	1.745500	-0.001544	1.744120
16		1.745710	0.00084	1.745500	-0.000210	1.880530
17		1.745405	0.00085	1.745500	0.000095	2.017090
18		1.745126	0.00086	1.745500	0.000374	2.153560
19		1.745847	0.00086	1.745500	-0.000347	2.290050
20		1.745628	0.00087	1.745500	-0.000128	2.426530

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot P(I-1))}{\sqrt{(\sum(R(I))^2) \cdot (\sum(P(I-1))^2)}}$

SERIAL CORRELATION 0.58382 RESIDUALS ORDERED ON CASE NUMBER

M 4



PLOT NUMBER									
2024AL ALLOY TEMP.=225 C STRESS=.70									
TIME BASE									
TOTAL TIME 100.0 MIN									
RECOVERY AT 29.3 MIN									
INCREMENT OF TIME 0.505 MIN									
INPUT VARIABLES									
LINE	STRESS	CO	CT	GO	GT	W2	EX	GENB	TIME
NUMBER	(PSI)								ENT
1	20916.0	85130E-04	0.23613E-08	1.0000e-44	3.6102E-03	7.5620E-02	29.50800	80.00000	
0.450E-02									
0.400E-02									
0.350E-02									
0.300E-02									
0.250E-02									
0.200E-02									
0.150E-02									
0.100E-02									
0.500E-03									
0.									
10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.421361	0.00579	1.407173	-0.014191	0.200360
2	1.442812	0.00375	1.457320	0.014508	1.200000
3	1.471345	0.00770	1.464550	-0.006795	3.200000
4	1.497719	0.00243	1.497810	0.000091	5.200000
5	1.527732	0.00234	1.508910	-0.018822	7.200000
6	1.521301	0.00335	1.515741	-0.005560	9.200000
7	1.534206	0.00234	1.527510	-0.006696	11.200000
8	1.566077	0.00231	1.539000	-0.027077	13.200000
9	1.557192	0.00227	1.550440	-0.006752	15.200000
10	1.572555	0.00219	1.565220	-0.007335	17.200000
11	1.596928	0.00210	1.579120	-0.017838	19.200000
12	1.606432	0.00199	1.593450	-0.012982	21.200000
13	1.613133	0.00190	1.610650	-0.002483	23.200000
14	1.625210	0.00184	1.622610	-0.002600	25.200000
15	1.629112	0.00182	1.637870	0.008758	27.200000
16	1.645497	0.00181	1.647910	0.002413	29.200000
17	1.651424	0.00185	1.656500	0.005076	31.200000
18	1.661752	0.00195	1.666530	0.004778	33.200000
19	1.672143	0.00211	1.676540	0.004402	35.200000
20	1.682016	0.00231	1.685160	0.003144	37.200000
21	1.691597	0.00255	1.693760	0.002163	39.200000
22	1.700914	0.00282	1.699480	-0.001434	41.200000
23	1.709991	0.00312	1.703790	-0.006201	43.200000
24	1.719133	0.00345	1.715250	-0.003883	45.200000

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R(I) \cdot R(I-1))}{\sqrt{\sum (R(I))^2 \cdot \sum (R(I-1))^2}}$

SERIAL CORRELATION 0.55162 RESIDUALS ORDERED ON CASE NUMBER

A1-5

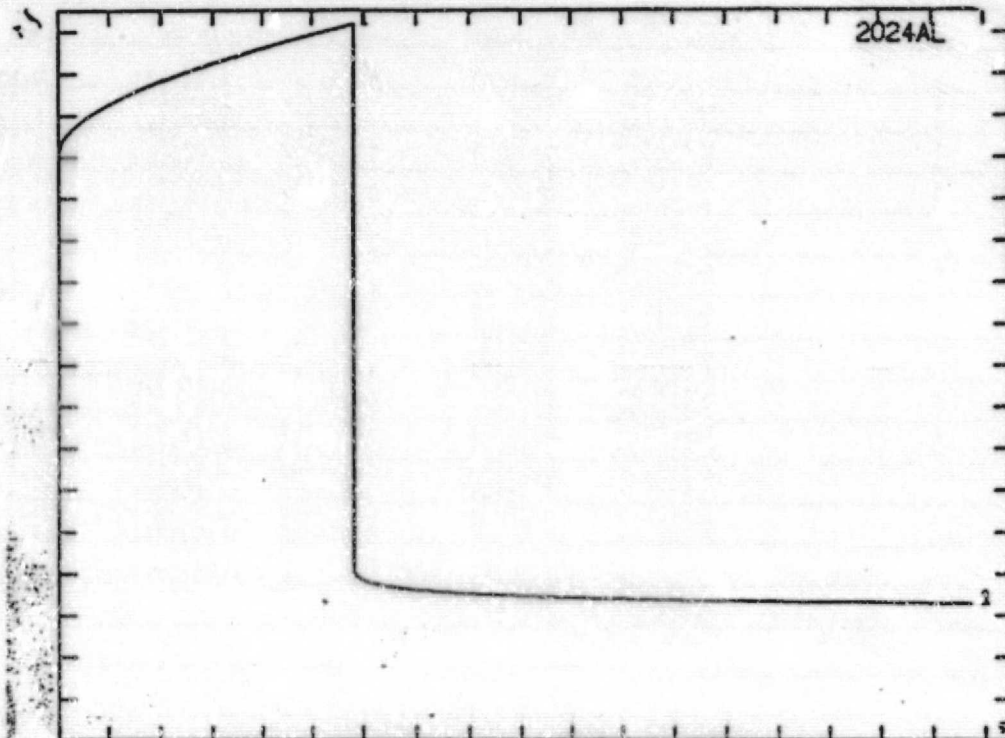
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	0.397521	0.00162	0.401230	0.003709	0.001720
2	0.336320	0.00097	0.360030	0.023710	0.013870
3	0.380721	0.00060	0.376300	-0.004421	0.036020
4	0.376667	0.00074	0.374000	-0.002667	0.053170
5	0.373642	0.00073	0.372570	-0.001072	0.070330
6	0.364591	0.00075	0.363970	-0.000621	0.133940
7	0.358372	0.00075	0.362540	0.004168	0.207550
8	0.354682	0.00072	0.353240	-0.001442	0.276180
9	0.351610	0.00068	0.352510	0.000900	0.344770
10	0.348748	0.00064	0.347940	-0.000808	0.413380
11	0.346521	0.00060	0.346780	0.000259	0.481990
12	0.344617	0.00057	0.342480	-0.002137	0.550600
13	0.341509	0.00053	0.338180	-0.003329	0.618220
14	0.339053	0.00051	0.338150	-0.000903	0.685840
15	0.337044	0.00052	0.337610	0.000566	0.753460
16	0.335360	0.00055	0.336730	0.001370	0.821080
17	0.333920	0.00058	0.335510	0.001590	0.888700
18	0.332669	0.00063	0.333360	0.000691	0.956320
19	0.331567	0.00067	0.332450	0.000883	1.023940
20	0.330592	0.00071	0.329550	-0.001042	1.091560
21	0.329715	0.00076	0.329560	-0.000155	1.159180
22	0.328922	0.00080	0.328150	-0.000772	1.226800
23	0.328202	0.00084	0.326710	-0.001492	1.294420

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R(I) \cdot R(I-1))}{\sqrt{\sum (R(I))^2 \cdot \sum (R(I-1))^2}}$

SERIAL CORRELATION 0.43634 RESIDUALS ORDERED ON CASE NUMBER

A1-5

ORIGINAL PAGE 1
OF POOR QUALITY



2024AL ALLOY TEMP. 4250 C STRESS. 90										
TIME. 0.00										
TOTAL TIME 177.5 MIN										
RECORDING AT 34.3 MIN										
INCREMENT OF TIME 0.001 MIN										
INPUT VARIABLES										
LINE	STRESS	CO	CI	EO	CI	FO	SA	CTD	TONR	ENT
NUMBER	(PSI)									
1	11150.0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	58.00000	2.41255
0.1700E-02										
0.1800E-02										
0.1900E-02										
0.2000E-02										
0.2100E-02										
0.2200E-02										
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1.9800E-01										
1.9900E-01										
2.0000E-01										

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.92722	0.00167	1.921390	-0.00583	0.116700
2	2.151135	0.00190	2.157910	0.006775	1.116700
3	2.220132	0.00171	2.225700	0.005568	2.116700
4	2.342945	0.00150	2.340180	-0.002765	3.116700
5	2.422945	0.00154	2.422220	-0.000725	4.116700
6	2.485009	0.00147	2.480150	-0.004859	5.116700
7	2.536045	0.00139	2.530340	-0.005705	6.116700
8	2.581352	0.00130	2.577900	-0.003452	7.116700
9	2.521144	0.00122	2.514110	-0.007034	8.116700
10	2.557117	0.00114	2.553740	-0.003377	9.116700
11	2.570292	0.00108	2.569010	-0.001282	10.116700
12	2.723024	0.00103	2.722730	-0.000294	11.116700
13	2.749121	0.00100	2.751700	0.002579	12.116700
14	2.775391	0.00100	2.780900	0.005509	13.116700
15	2.801173	0.00103	2.802380	0.001207	14.116700
16	2.825156	0.00107	2.827730	0.002572	15.116700
17	2.850021	0.00114	2.853070	0.003049	16.116700
18	2.869029	0.00122	2.871130	0.002101	17.116700
19	2.892747	0.00132	2.892900	0.000153	18.116700
20	2.910444	0.00142	2.911000	0.000556	19.116700
21	2.930125	0.00154	2.925490	-0.004635	20.116700
22	2.948369	0.00166	2.947210	-0.001159	21.116700
23	2.955673	0.00170	2.954450	-0.001223	22.116700

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)-R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)+\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.52429 CASE NUMBER

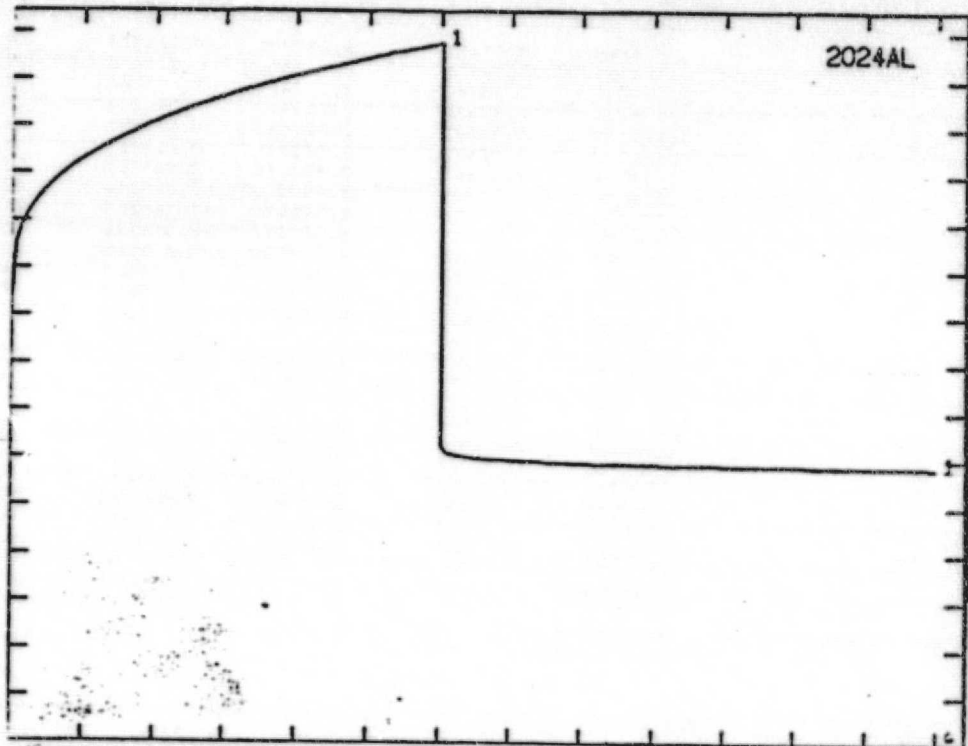
AN 6

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.236331	0.00286	1.241880	0.005549	0.001990
2	1.220228	0.00161	1.216540	-0.003688	0.018590
3	1.213377	0.00135	1.209300	-0.004077	0.035190
4	1.208663	0.00128	1.204230	-0.004433	0.051500
5	1.205015	0.00128	1.202060	-0.002955	0.068400
6	1.195296	0.00132	1.198440	0.003144	0.134300
7	1.189141	0.00129	1.194820	0.005679	0.201210
8	1.184662	0.00121	1.187570	0.002908	0.267610
9	1.181170	0.00112	1.185400	0.004230	0.334020
10	1.178332	0.00104	1.180330	0.001998	0.400420
11	1.177096	0.00100	1.176710	-0.000386	0.433620
12	1.174908	0.00095	1.176710	0.001802	0.500030
13	1.173025	0.00094	1.169470	-0.003555	0.566430
14	1.171379	0.00096	1.169470	-0.001909	0.632840
15	1.169225	0.00100	1.165850	-0.003375	0.699240
16	1.168627	0.00107	1.165850	-0.002777	0.765650
17	1.167460	0.00116	1.165850	-0.001610	0.832050
18	1.164141	0.00150	1.165850	0.001709	1.064470
19	1.163361	0.00160	1.164400	0.001039	1.130870
20	1.163992	0.00166	1.164400	0.000408	1.164070

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)-R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)+\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.47864 CASE NUMBER

ORIGINAL PAGE IS
OF POOR QUALITY



PLOT NUMBER										
2024AL ALLOY TEMP. 4752 C STRESS-60										
TIME BASE										
TOTAL TIME 129.3 MIN										
RECOVERY AT 60.2 MIN										
INCREMENT OF TIME 0.002 MIN										
INPUT VARIABLES										
LINE	STRESS	CO	CT	GO	GT	QZ	EA	CEH3	TIME	ENT
NUMBER	EPSI()									
1	15783.0	11326E-030	13283E-031	101009	579301	474000	511750	11383E-02	60.25570	1.21471
0.100E-02										
0.200E-02										
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0.100E+05										
0.200E+05										
0.300E+05										
0.400E+05										
0.500E+05										
0.600E+05										
0.700E+05										
0.800E+05										
0.900E+05										
0.100E+06										
0.200E+06										
0.300E+06										
0.400E+06										
0.500E+06										
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0.800E+10										
0.900E+10										
0.100E+11										
0.200E+11										
0.300E+11										
0.400E+11										
0.500E+11										
0.600E+11										
0.700E+11										
0.800E+11										
0.900E+11										
0.100E+12										
0.200E+12										
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0.500E+12										
0.600E+12										
0.700E+12										
0.800E+12										
0.900E+12										
0.100E+13										
0.200E+13										
0.300E+13										
0.400E+13										
0.500E+13										
0.600E+13										
0.700E+13										
0.800E+13										
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0.100E+14										
0.200E+14										
0.300E+14										
0.400E+14										
0.500E+14										
0.600E+14										
0.700E+14										
0.800E+14										
0.900E+14										
0.100E+15										
0.200E+15										
0.300E+15										
0.400E+15										
0.500E+15										
0.600E+15										
0.700E+15										
0.800E+15										
0.900E+15										
0.100E+16										
0.200E+16										
0.300E+16										
0.400E+16										
0.500E+16										
0.600E+16										
0.700E+16										
0.800E+16										
0.900E+16										
0.100E+17										
0.200E+17										
0.300E+17										
0.400E+17										
0.500E+17										
0.600E+17										

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		2.325264	0.01682	2.279990	-0.045374	0.100000
2		2.505318	0.00913	2.526650	0.021332	1.100000
3		2.591545	0.00760	2.627430	0.035885	2.100000
4		2.774536	0.00590	2.755170	-0.019366	3.100000
5		2.754369	0.00665	2.822060	0.067691	4.100000
6		2.868722	0.00557	2.870710	0.001988	5.100000
7		2.952964	0.00641	2.954120	0.001156	6.100000
8		3.004774	0.00575	2.999300	-0.005474	7.100000
9		3.056720	0.00607	3.044490	-0.012230	8.100000
10		3.116760	0.00578	3.100090	-0.016670	9.100000
11		3.171755	0.00547	3.155700	-0.016055	10.100000
12		3.224581	0.00518	3.204350	-0.020231	11.100000
13		3.273620	0.00494	3.253010	-0.020610	12.100000
14		3.319523	0.00477	3.294730	-0.024793	13.100000
15		3.362775	0.00469	3.343370	-0.019405	14.100000
16		3.403750	0.00471	3.388550	-0.015200	15.100000
17		3.442764	0.00484	3.433730	-0.009034	16.100000
18		3.479994	0.00507	3.475640	-0.004354	17.100000
19		3.515695	0.00540	3.520620	0.004925	18.100000
20		3.550007	0.00580	3.553850	0.003843	19.100000
21		3.583763	0.00627	3.593610	0.010542	20.100000
22		3.616492	0.00679	3.624830	0.008338	21.100000
23		3.648478	0.00734	3.659640	0.011162	22.100000
24		3.675313	0.00793	3.690920	0.015607	23.100000
25		3.686565	0.00815	3.704820	0.018255	24.100000

SERIAL CORRELATION OF RESIDUALS = $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.64520 RESIDUALS ORDERED ON CASE NUMBER

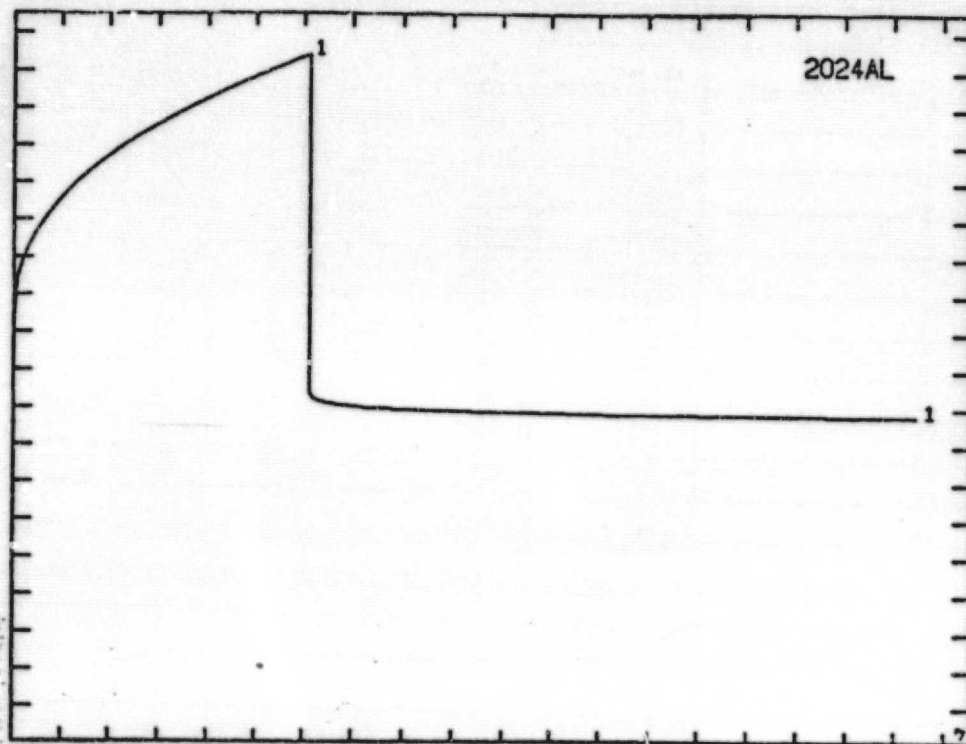
A 7

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		1.358215	0.00314	1.869790	0.011575	0.001630
2		1.539729	0.00126	1.635030	-0.005301	0.017970
3		1.331463	0.00152	1.826000	-0.004537	0.034310
4		1.825639	0.00141	1.819740	-0.005899	0.050930
5		1.821056	0.00138	1.815570	-0.005488	0.066790
6		1.817254	0.00138	1.814180	-0.003074	0.083330
7		1.806283	0.00147	1.807230	0.000947	0.100000
8		1.796354	0.00150	1.800280	0.003926	0.116670
9		1.788805	0.00142	1.793330	0.004525	0.133330
10		1.785127	0.00136	1.787770	0.002643	0.150000
11		1.774983	0.00115	1.782210	0.007227	0.166670
12		1.776904	0.00110	1.777340	0.000436	0.183330
13		1.773046	0.00105	1.775950	0.002904	0.200000
14		1.769853	0.00099	1.772470	0.002617	0.216670
15		1.768465	0.00098	1.769000	0.000535	0.233330
16		1.766019	0.00099	1.765520	-0.000499	0.250000
17		1.764932	0.00100	1.765520	0.000588	0.266670
18		1.762780	0.00106	1.762050	-0.000730	0.283330
19		1.761272	0.00113	1.762050	0.000778	0.300000
20		1.759762	0.00121	1.758570	-0.001192	0.316670
21		1.759069	0.00126	1.758570	-0.000499	0.333330
22		1.757792	0.00135	1.758570	0.000778	0.350000
23		1.756640	0.00144	1.755100	-0.001540	0.366670
24		1.755593	0.00153	1.751620	-0.003973	0.383330
25		1.755346	0.00155	1.751620	-0.003726	0.400000

SERIAL CORRELATION OF RESIDUALS = $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.43730 RESIDUALS ORDERED ON CASE NUMBER

A 7



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PLOT NUMBER
2024AL ALLOY TEMP. 4250 C STRESS. 95

TIME BASE
TOTAL TIME 124.5 MIN
RECOVERY AT 61.2 MIN
INCREPENT OF TIME 0.942 MIN

INPUT VARIABLES

LINE STRESS    CO      CT      GO      GT      'GZ      KA      CEND      TONE      ENT
NUMBER EPSI17

1 17235.3 166338-010.132338-081.231000.149001.340000.404487.172574-02 67.22722 1.31766
0.3806-02
0.3606-02
0.3406-02
0.3206-02
0.3006-02
0.2806-02
0.2606-02
0.2406-02
0.2206-02
0.2006-02
0.1806-02
0.1606-02
0.1406-02
0.1206-02
0.1006-02
0.8006-02
0.6006-02
0.4006-02
0.2006-02
0.
10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.777767	0.01133	2.752930	-0.019237	0.200000
2	2.977273	0.01580	2.997770	0.019527	1.200000
3	3.081455	0.01486	3.093230	0.011774	2.200000
4	3.157741	0.01457	3.167230	0.009489	3.200000
5	3.320174	0.01444	3.322640	0.002466	4.200000
6	3.416560	0.01433	3.433640	0.017080	5.200000
7	3.530274	0.01425	3.529640	-0.000634	12.200000
8	3.617772	0.01405	3.576640	-0.041132	15.200000
9	3.680274	0.01382	3.655640	-0.024634	18.200000
10	3.743274	0.01359	3.712740	-0.030534	21.200000
11	3.830127	0.01324	3.855440	0.025313	24.200000
12	3.855333	0.01319	3.870240	0.014907	27.200000
13	3.886557	0.01309	3.892440	0.005883	29.200000
14	3.937723	0.01300	3.934840	0.003117	32.200000
15	3.978122	0.01293	3.981240	0.003118	35.200000
16	4.020131	0.01304	4.013240	-0.006891	38.200000
17	4.060752	0.01317	4.055240	-0.005512	41.200000
18	4.098129	0.01336	4.099640	0.001511	44.200000
19	4.134566	0.01362	4.127240	-0.007326	47.200000
20	4.169530	0.01391	4.166240	-0.003290	50.200000
21	4.203164	0.01424	4.203240	0.000076	53.200000
22	4.235590	0.01460	4.240240	0.004650	56.200000
23	4.266913	0.01497	4.269440	0.002527	59.200000
24	4.298333	0.01526	4.292340	-0.006007	61.360000

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-\bar{R})(R(I-1)-\bar{R})}{\sqrt{(\sum(R(I)-\bar{R})^2)(\sum(R(I-1)-\bar{R})^2)}}$

SERIAL CORRELATION: 0.20422
RESIDUALS ORDERED ON CASE NUMBER

M-3

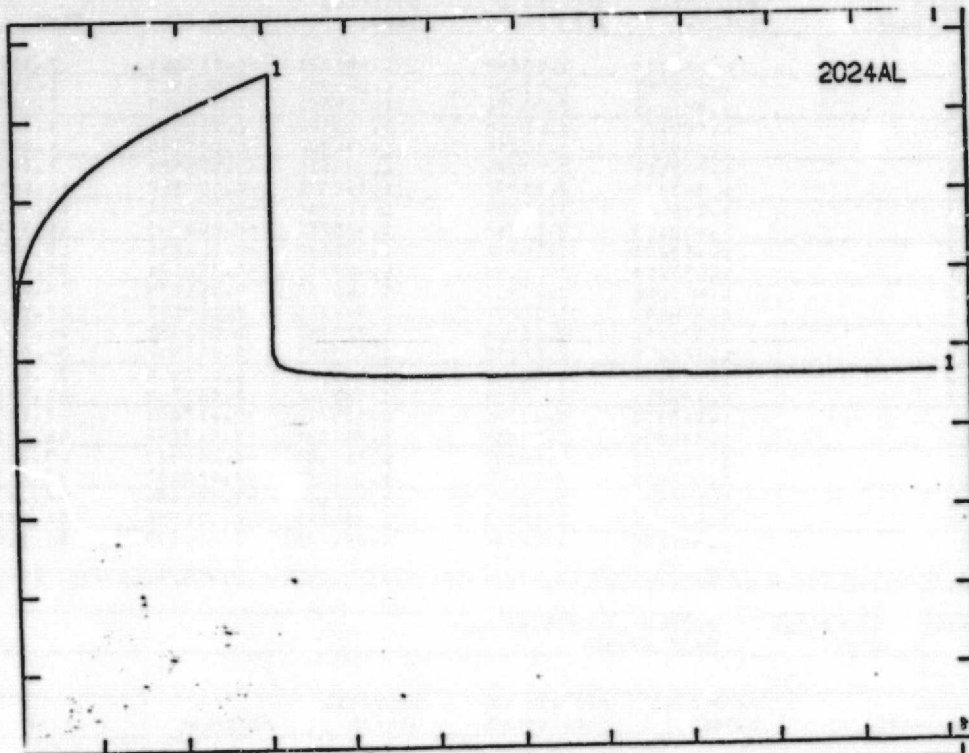
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.473994	0.00275	2.471630	-0.002364	0.003250
2	2.440819	0.00148	2.442020	0.001201	0.017330
3	2.426091	0.00126	2.427220	0.001129	0.035850
4	2.407000	0.00124	2.409480	0.002480	0.058430
5	2.403210	0.00125	2.405020	0.001810	0.084750
6	2.357935	0.00121	2.390220	0.032285	0.149930
7	2.378762	0.00112	2.382820	0.004058	0.215120
8	2.372430	0.00103	2.372460	0.000030	0.280310
9	2.367870	0.00094	2.368020	0.000150	0.343670
10	2.361179	0.00081	2.360620	-0.000559	0.417380
11	2.356693	0.00074	2.353220	-0.003473	0.490260
12	2.353400	0.00070	2.345620	-0.007780	0.573660
13	2.350858	0.00069	2.345820	-0.005038	0.667010
14	2.346825	0.00070	2.345820	-0.001005	0.777390
15	2.347154	0.00072	2.342860	-0.004294	1.127770
16	2.343752	0.00074	2.342860	-0.000892	1.238150
17	2.344555	0.00077	2.342860	-0.001695	1.368530
18	2.343519	0.00080	2.342860	-0.000659	1.513930
19	2.342611	0.00082	2.342860	0.000249	1.649260
20	2.341309	0.00085	2.342860	0.001551	1.779860
21	2.341092	0.00087	2.342860	0.001768	1.910040
22	2.340449	0.00090	2.342860	0.002411	2.040400
23	2.339866	0.00092	2.342860	0.002994	2.170600
24	2.339335	0.00094	2.342860	0.003525	2.301170
25	2.338852	0.00096	2.342860	0.004008	2.431550
26	2.338405	0.00098	2.342860	0.004454	2.561930

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-\bar{R})(R(I-1)-\bar{R})}{\sqrt{(\sum(R(I)-\bar{R})^2)(\sum(R(I-1)-\bar{R})^2)}}$

SERIAL CORRELATION: 0.31890
RESIDUALS ORDERED ON CASE NUMBER

M-6

ORIGINAL PAGE IS
OF POOR QUALITY



PLOT NUMBER									
2024AL ALLOY TEMP.=250 C STRESS=.73									
TIME BASE									
TOTAL TIME 218.5 MIN									
RECOVERY AT 61.4 MIN									
INCREMENT OF TIME 1.116 MIN									
INPUT VARIABLES									
LINE	STRESS	C0	C1	C2	C3	C4	C500	TIME	END
NUMBER	(PSI)								
1	18410.0	0.19131E-350	1.5233E-031	2.8800E-150	0.03	1.1060E-351	30.23249E-02	61.35000	4.451-5
0.450E-02									
0.400E-02									
0.350E-02									
0.300E-02									
0.250E-02									
0.200E-02									
0.150E-02									
0.100E-02									
0.500E-03									
0.									
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
220.0									

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PREJ. VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.199233	3.002695	1.191370	-0.007863	3.043333
2	1.239003	3.002409	1.244920	0.005917	1.043333
3	1.261645	3.002334	1.269753	0.008108	2.043333
4	1.279474	3.002309	1.282010	0.002536	3.043333
5	1.294715	3.002291	1.294960	0.002245	4.043333
6	1.312229	3.002245	1.319520	-0.007291	7.043333
7	1.352127	3.002297	1.352520	-0.000393	10.043333
8	1.390500	3.002245	1.376940	-0.013560	13.043333
9	1.412109	3.002287	1.405760	-0.006349	16.043333
10	1.433638	3.002276	1.421560	-0.012078	19.043333
11	1.453618	3.002263	1.447680	-0.005938	22.043333
12	1.472351	3.002249	1.463450	-0.008901	25.043333
13	1.490051	3.002237	1.509350	0.019299	28.043333
14	1.526878	3.002228	1.520860	-0.006018	31.043333
15	1.522953	3.002222	1.530940	0.007987	34.043333
16	1.538371	3.002222	1.545320	0.006949	37.043333
17	1.553211	3.002224	1.553960	-0.000749	40.043333
18	1.567535	3.002241	1.559710	-0.007825	43.043333
19	1.581394	3.002259	1.568350	-0.013044	46.043333
20	1.594433	3.002282	1.589930	-0.004503	49.043333
21	1.607489	3.002279	1.607190	-0.000299	52.043333
22	1.620594	3.002341	1.620140	-0.000454	55.043333
23	1.632976	3.002373	1.634530	0.001554	58.043333
24	1.641195	3.002397	1.641730	0.000535	60.116333

SERIAL CORRELATION OF RESIDUALS = $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.56781 RESIDUALS ORDERED ON CASE NUMBER

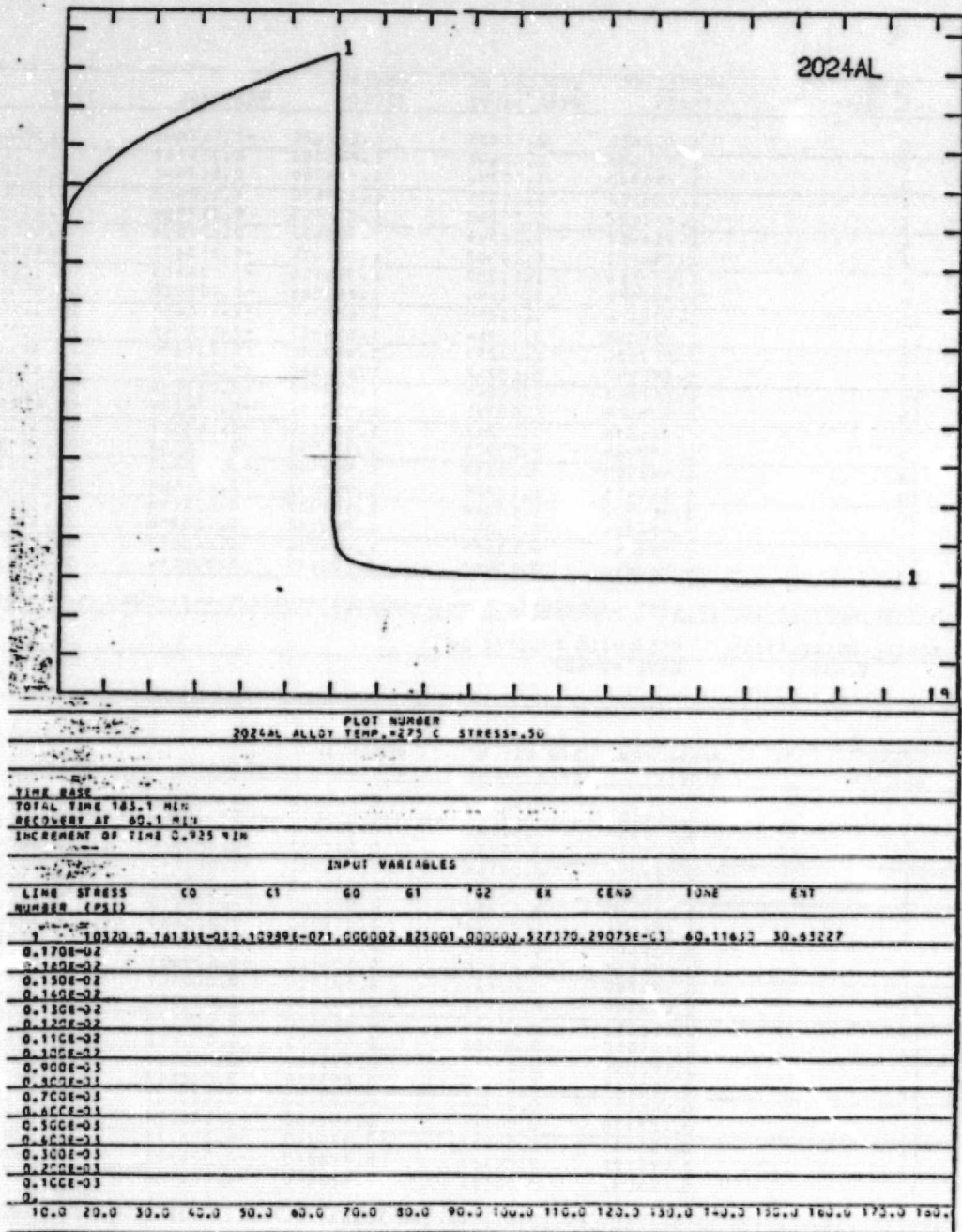
M 9

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PREJ. VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	0.415619	0.00352	0.411510	-0.004109	0.002770
2	0.402982	0.00248	0.404320	0.001338	0.005550
3	0.394464	0.00207	0.397120	0.002656	0.008320
4	0.388627	0.00197	0.371220	-0.002593	0.024950
5	0.386459	0.00197	0.359710	-0.003251	0.041590
6	0.348845	0.00188	0.351080	0.002235	0.058220
7	0.339401	0.00166	0.345320	0.005919	0.091490
8	0.336181	0.00157	0.335250	-0.000931	0.108120
9	0.333545	0.00148	0.330940	-0.002605	0.124760
10	0.326372	0.00125	0.313670	-0.012702	0.191300
11	0.318924	0.00108	0.313670	-0.005254	0.324370
12	0.314855	0.00106	0.309350	-0.005505	0.457450
13	0.312192	0.00109	0.306470	-0.005722	0.590520
14	0.310273	0.00113	0.307910	-0.002363	0.723600
15	0.308804	0.00118	0.310790	0.001986	0.856670
16	0.307633	0.00122	0.307910	-0.000277	0.989750
17	0.306670	0.00126	0.310790	0.004120	1.122820
18	0.305860	0.00129	0.310790	0.004930	1.255900
19	0.305166	0.00132	0.310790	0.005624	1.388970
20	0.304562	0.00135	0.302160	-0.002402	1.522050
21	0.304031	0.00138	0.305040	0.001009	1.655130
22	0.303558	0.00140	0.302160	-0.001398	1.788200
23	0.303135	0.00143	0.306470	0.003335	1.921280
24	0.302752	0.00145	0.306470	0.003718	2.054350

SERIAL CORRELATION OF RESIDUALS = $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.54106 RESIDUALS ORDERED ON CASE NUMBER

M 9



CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.538826	0.00938	1.520520	-0.017946	0.100000
2	1.626548	0.00459	1.641350	0.014762	1.100000
3	1.656912	0.00391	1.684750	0.027838	2.100000
4	1.696252	0.00375	1.709170	0.012918	3.100000
5	1.731622	0.00363	1.737660	0.006038	4.100000
6	1.756412	0.00349	1.763430	0.007018	5.100000
7	1.792170	0.00333	1.778350	-0.013820	6.100000
8	1.823114	0.00315	1.798700	-0.024416	7.100000
9	1.821982	0.00295	1.812260	-0.009278	8.100000
10	1.839226	0.00279	1.828540	-0.010686	9.100000
11	1.855166	0.00264	1.844820	-0.010346	10.100000
12	1.870330	0.00253	1.858380	-0.011650	11.100000
13	1.883987	0.00247	1.874660	-0.009373	12.100000
14	1.897158	0.00245	1.889580	-0.007549	13.100000
15	1.909676	0.00251	1.903150	-0.003476	14.100000
16	1.921593	0.00262	1.918270	-0.003323	15.100000
17	1.932985	0.00273	1.931630	-0.001355	16.100000
18	1.943939	0.00293	1.942490	-0.001449	17.100000
19	1.954411	0.00323	1.956050	0.001639	18.100000
20	1.964532	0.00349	1.972330	0.007798	19.100000
21	1.974324	0.00374	1.983190	0.008866	20.100000
22	1.983757	0.00409	1.994030	0.010273	21.100000
23	1.989986	0.00433	2.002170	0.012184	22.100000

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-R(I-1))}{\sqrt{(\sum(R(I)-R(I-1))^2 + \sum(R(I-1)-R(I-2))^2)}}$

SERIAL CORRELATION 0.65946 RESIDUALS ORDERED ON CASE NUMBER

A1 10

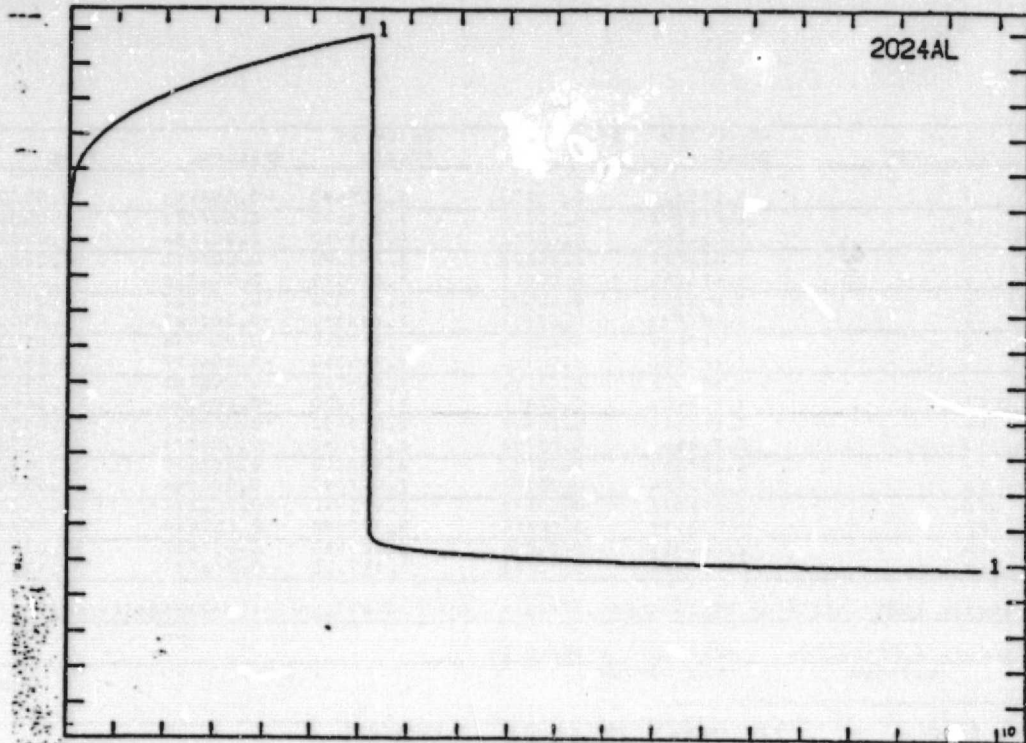
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	0.564251	0.00319	0.571080	0.006829	0.003210
2	0.568159	0.00184	0.542590	-0.005569	0.033350
3	0.541144	0.00154	0.537170	-0.003974	0.067490
4	0.536214	0.00146	0.533100	-0.003114	0.099930
5	0.532333	0.00145	0.531740	-0.000593	0.131770
6	0.521690	0.00153	0.533600	0.000910	0.260320
7	0.514691	0.00153	0.518180	0.003489	0.388880
8	0.509449	0.00145	0.503680	-0.005769	0.517440
9	0.505267	0.00135	0.504610	-0.000657	0.645990
10	0.501799	0.00124	0.501900	0.000101	0.774550
11	0.498849	0.00115	0.497830	-0.001019	0.903100
12	0.496292	0.00109	0.496470	0.000178	1.031660
13	0.494042	0.00103	0.496470	0.002428	1.160210
14	0.492039	0.00112	0.495120	0.003081	1.288770
15	0.490241	0.00120	0.493760	0.003519	1.417320
16	0.488612	0.00131	0.492400	0.003788	1.545880
17	0.487128	0.00144	0.492400	0.005272	1.674430
18	0.486433	0.00152	0.484260	-0.002173	1.732710
19	0.485127	0.00167	0.478840	-0.006287	1.867270
20	0.483922	0.00183	0.477480	-0.006442	1.995820

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-R(I-1))}{\sqrt{(\sum(R(I)-R(I-1))^2 + \sum(R(I-1)-R(I-2))^2)}}$

SERIAL CORRELATION 0.41240 RESIDUALS ORDERED ON CASE NUMBER

A1 10

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PLOT NUMBER										
2024AL ALLOY TEMP. 4275 C STRESS 60										
TIME BASE										
TOTAL TIME 93.3 MIN										
RECOVERY AT 31.1 MIN										
INCREMENT OF TIME 0.479 MIN										
INPUT VARIABLES										
LINE	STRESS	60	61	62	63	64	65	66	67	68
NUMBER	(PSI)									
1	12345.0	133836-050	109898-071	037003	337000	202800	390010	442146-05	31.115-0	0.42902
0.200E-02										
0.190E-02										
0.180E-02										
0.170E-02										
0.160E-02										
0.150E-02										
0.140E-02										
0.130E-02										
0.120E-02										
0.110E-02										
0.100E-02										
0.900E-03										
0.800E-03										
0.700E-03										
0.600E-03										
0.500E-03										
0.400E-03										
0.300E-03										
0.200E-03										
0.100E-03										
0.										
5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0
60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0			

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.515838	0.00513	1.607690	-0.008148	0.050000
2	1.711573	0.00237	1.713655	0.002272	1.050000
3	1.754746	0.00210	1.761930	0.007184	2.050000
4	1.735777	0.00208	1.793390	0.007113	3.050000
5	1.513154	0.00208	1.817510	0.004356	4.050000
6	1.535312	0.00194	1.855330	-0.001282	6.050000
7	1.391793	0.00188	1.886370	-0.003423	8.050000
8	1.722466	0.00175	1.917550	-0.004916	10.050000
9	1.747777	0.00164	1.945350	-0.004427	12.050000
10	1.774575	0.00154	1.966190	-0.008385	14.050000
11	1.777406	0.00148	1.991200	-0.006206	16.050000
12	2.118644	0.00147	2.013430	-0.005214	18.050000
13	2.338561	0.00152	2.037050	-0.001511	20.050000
14	2.357359	0.00152	2.059290	0.001931	22.050000
15	2.375196	0.00177	2.077350	0.002154	24.050000
16	2.172173	0.00195	2.095410	0.003217	26.050000
17	2.138452	0.00215	2.112090	0.003638	28.050000
18	2.124053	0.00217	2.125980	0.001927	30.050000
19	2.132379	0.00253	2.137100	0.004721	31.150000

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-\bar{R})(I-1)}{\sqrt{(\sum(R(I))^2-2*\bar{R}*\sum(R(I)-1))}}$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.61888 CASE NUMBER

At 11

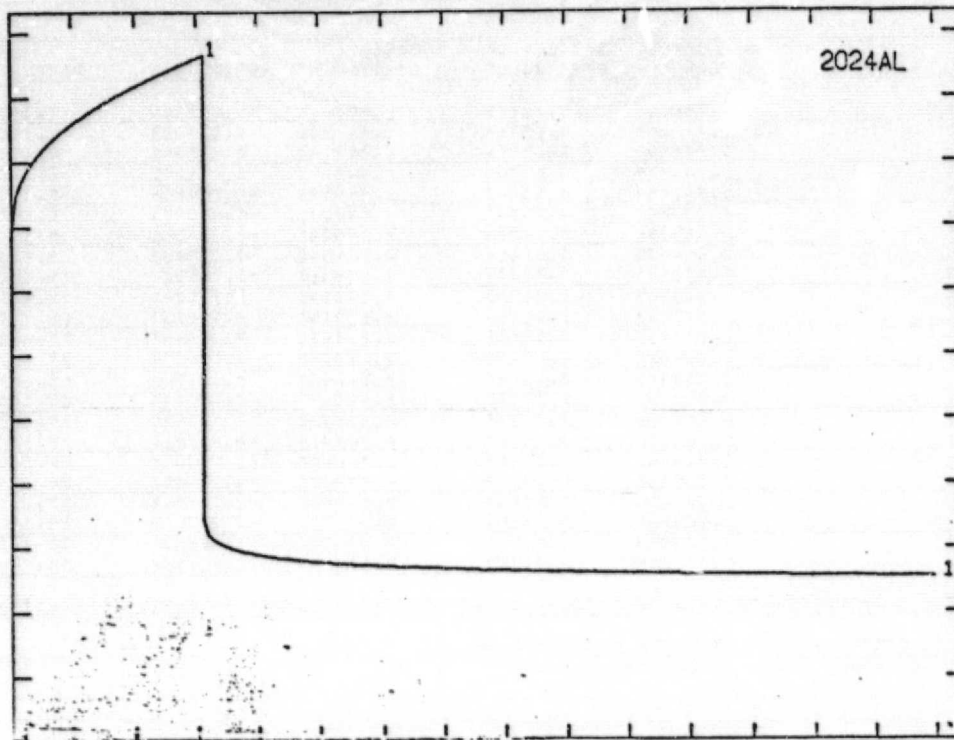
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	0.672018	0.00362	0.675310	0.003292	0.000640
2	0.654701	0.00273	0.651690	-0.003011	0.007060
3	0.628138	0.00193	0.628070	-0.000068	0.039170
4	0.614749	0.00184	0.614170	-0.000579	0.071270
5	0.597899	0.00191	0.591940	-0.005959	0.135470
6	0.578220	0.00197	0.579430	0.001210	0.263880
7	0.568501	0.00193	0.573880	0.005279	0.360190
8	0.561238	0.00185	0.571100	0.009862	0.456500
9	0.547608	0.00161	0.540530	-0.007078	0.713320
10	0.538646	0.00142	0.532190	-0.006456	0.970140
11	0.532156	0.00130	0.529410	-0.002746	1.226970
12	0.527174	0.00126	0.525240	-0.001934	1.483790
13	0.523194	0.00127	0.528020	0.004826	1.740610
14	0.519921	0.00132	0.523850	0.003929	1.997430
15	0.517169	0.00140	0.523850	0.006681	2.254250
16	0.514814	0.00149	0.517740	0.002926	2.511080
17	0.512770	0.00158	0.508570	-0.004200	2.767900
18	0.510974	0.00167	0.506350	-0.004624	3.024720
19	0.509382	0.00176	0.506350	-0.003032	3.281540
20	0.507956	0.00184	0.506350	-0.001606	3.538360
21	0.506671	0.00192	0.509960	0.003289	3.795180

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-\bar{R})(I-1)}{\sqrt{(\sum(R(I))^2-2*\bar{R}*\sum(R(I)-1))}}$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.28056 CASE NUMBER

At 11

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PLOT NUMBER									
2024AL ALLOY TEMP. 4275 C STRESS=95									
TIME BASE									
TOTAL TIME 149.7 MIN									
RECOVERY AT 31.2 MIN									
INCREMENT OF TIME 0.750 MIN									
INPUT VARIABLES									
LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7
NUMBER (P51)									
1	13516.0	2.20295E-03	0.12985E-07	0.02900E-03	0.33500E-03	0.16330E-03	0.21500E-03	0.7224E-03	31.1500
0.220E-02									
0.200E-02									
0.180E-02									
0.160E-02									
0.140E-02									
0.120E-02									
0.100E-02									
0.800E-03									
0.600E-03									
0.400E-03									
0.200E-03									
0									
	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0
	100.0	110.0	120.0	130.0	140.0	150.0			

C-2

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.734616	1.00615	1.727460	-0.007216	0.160000
2	1.413357	1.00314	1.444020	0.031663	1.160000
3	1.446699	1.00226	1.495140	0.048441	2.160000
4	1.444679	1.00248	1.446060	0.001381	3.160000
5	1.930695	1.00243	1.939790	-0.009095	5.160000
6	2.129530	1.00237	2.026230	-0.103300	6.160000
7	2.053551	1.00224	2.055390	0.001839	7.160000
8	2.044432	1.00214	2.044540	-0.000108	9.160000
9	2.122633	1.00216	2.116410	-0.006223	11.160000
10	2.144779	1.00195	2.151140	0.006361	12.160000
11	2.173238	1.00184	2.179290	0.006052	14.160000
12	2.196293	1.00175	2.204450	0.008157	15.160000
13	2.214120	1.00169	2.223020	0.008900	17.160000
14	2.238313	1.00164	2.244890	0.006577	18.160000
15	2.254743	1.00170	2.259470	0.004727	20.160000
16	2.277442	1.00177	2.281330	0.003888	21.160000
17	2.296174	1.00184	2.295910	-0.000264	23.160000
18	2.313852	1.00203	2.310490	-0.003362	24.160000
19	2.331916	1.00221	2.325070	-0.006846	26.160000
20	2.347479	1.00242	2.346930	-0.000549	27.160000
21	2.363526	1.00264	2.361510	-0.002016	29.160000
22	2.373968	1.00283	2.376090	0.002122	30.160000
23	2.375204	1.00292	2.376090	0.000886	30.247000

SERIAL CORRELATION OF RESIDUALS= $\sum(R(I) \cdot R(I-1)) / \sqrt{\sum(R(I))^2 \cdot \sum(R(I-1))^2}$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.48676 CASE NUMBER

PA 12

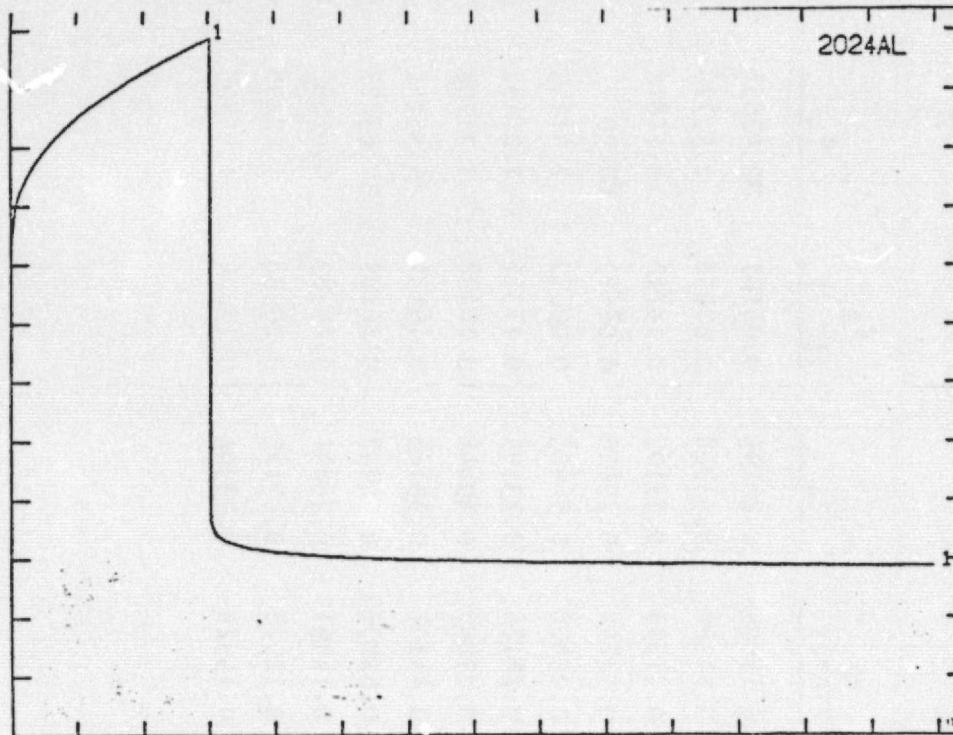
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	0.706266	0.00405	0.714280	0.008014	0.003300
2	0.675309	0.00213	0.670550	-0.004759	0.036350
3	0.661952	0.00183	0.655970	-0.005982	0.069350
4	0.552878	0.00179	0.648690	-0.004188	0.102350
5	0.545975	0.00180	0.641400	-0.004525	0.135400
6	0.528339	0.00181	0.626820	-0.001519	0.267500
7	0.517886	0.00170	0.619530	0.001644	0.399600
8	0.610666	0.00156	0.612240	0.001574	0.531700
9	0.606491	0.00145	0.612240	0.005749	0.630780
10	0.600110	0.00129	0.604950	0.004840	0.828950
11	0.595396	0.00117	0.597670	0.002274	1.027030
12	0.591730	0.00111	0.597670	0.005940	1.225230
13	0.588775	0.00109	0.597670	0.008895	1.423380
14	0.586327	0.00111	0.583090	-0.003237	1.621530
15	0.584258	0.00114	0.583090	-0.001168	1.819680
16	0.582480	0.00119	0.583090	0.000610	2.017830
17	0.580930	0.00125	0.581630	0.000700	2.215980
18	0.579564	0.00130	0.580170	0.000606	2.414130
19	0.578349	0.00136	0.580170	0.001821	2.612290
20	0.577260	0.00142	0.577260	0.000000	2.810440
21	0.576275	0.00148	0.577260	0.000985	3.008590
22	0.575380	0.00153	0.569970	-0.005410	3.206740
23	0.574562	0.00159	0.568510	-0.006052	3.404890
24	0.573811	0.00164	0.567050	-0.006761	3.603040

SERIAL CORRELATION OF RESIDUALS= $\sum(R(I) \cdot R(I-1)) / \sqrt{\sum(R(I))^2 \cdot \sum(R(I-1))^2}$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.47869 CASE NUMBER

PA 12

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PLOT NUMBER										
2024AL ALLOY TEMP. 275 C STRESS=70										
TIME BASE										
TOTAL TIME 139.4 MIN										
RECOVERY AT 30.3 MIN										
INCREPENT OF TIME 0.704 MIN										
INPUT VARIABLES										
LINE	STRESS	CO	CT	GO	GT	102	EA	CEND	TIME	END
NUMBER	(PST)									
1	14445.0	17614E-030	10989E-071	00300	040000	332100	419060	54682E-03	30.28000	1.94305
0.240E-02										
0.220E-02										
0.200E-02										
0.180E-02										
0.160E-02										
0.140E-02										
0.120E-02										
0.100E-02										
0.800E-03										
0.600E-03										
0.400E-03										
0.200E-03										
0.										
10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0
										120.0
										130.0
										140.0

Table 4. Parameters for 2024-T4 Aluminum Alloy

Temperature (°C)	Stress (MPa)	t_a (min)	ϵ_0 (10^{-3})	C' (10^{-3})	n	C_0 (10^{-3})	a_σ	C_{end} (10^{-3})
225	103	61.1167	1.71011	0.15000	0.26295	0.04167	32.43631	0.43541
225	124	60.28337	2.12014	0.14368	0.53768	0.08878	2.57728	1.43643
225	139	60.27	2.32197	0.31333	0.37102	0.14290	0.11812	1.66386
225	144	29.308	2.77983	0.11644	0.73620	0.08513	80.00	1.73003
250	91	58.3	1.40718	0.03408	0.54463	0.09897	2.41253	0.30332
250	109	60.2367	1.85938	0.28126	0.33195	0.11326	1.21471	1.13831
250	118	61.2	2.21550	0.27857	0.40448	0.14438	1.31766	1.72574
250	127	61.36	2.53834	0.41161	0.35163	0.19131	4.45145	2.32490
275	71	60.1163	1.18402	0.05271	0.52737	0.16183	30.63227	0.29075
275	85	31.115	1.47651	0.14491	0.36801	0.13383	0.42662	0.44218
275	92	31.15	1.57918	0.12970	0.42180	0.20998	1.22208	0.47224
275	100	30.28	1.66339	0.15924	0.43906	0.17614	1.94305	0.54882

Table 5. Parameters for 2024-T4 Aluminum Alloy

Temperature (°C)	Stress (MPa)	$A(0)$ (10^{-6})	C_i (10^{-9})	g_0	g_1	g_2
225	103	11.446	2.36129	1.00	10.615	1.00
225	124			1.033	14.66	0.3852
225	139			1.045	10.03	0.3084
225	144			1.16	16.4439	3.6102
250	91	10.701	1.32829	1.00	3.152	1.00
250	109			1.101	9.679	1.479
250	118			1.211	10.189	1.346
250	127			1.288	9.15	3.11
275	71	11.4732	10.9891	1.00	2.825	1.00
275	85			1.039	3.837	0.2028
275	92			1.026	2.635	0.3633
275	100			1.003	4.04	0.3323

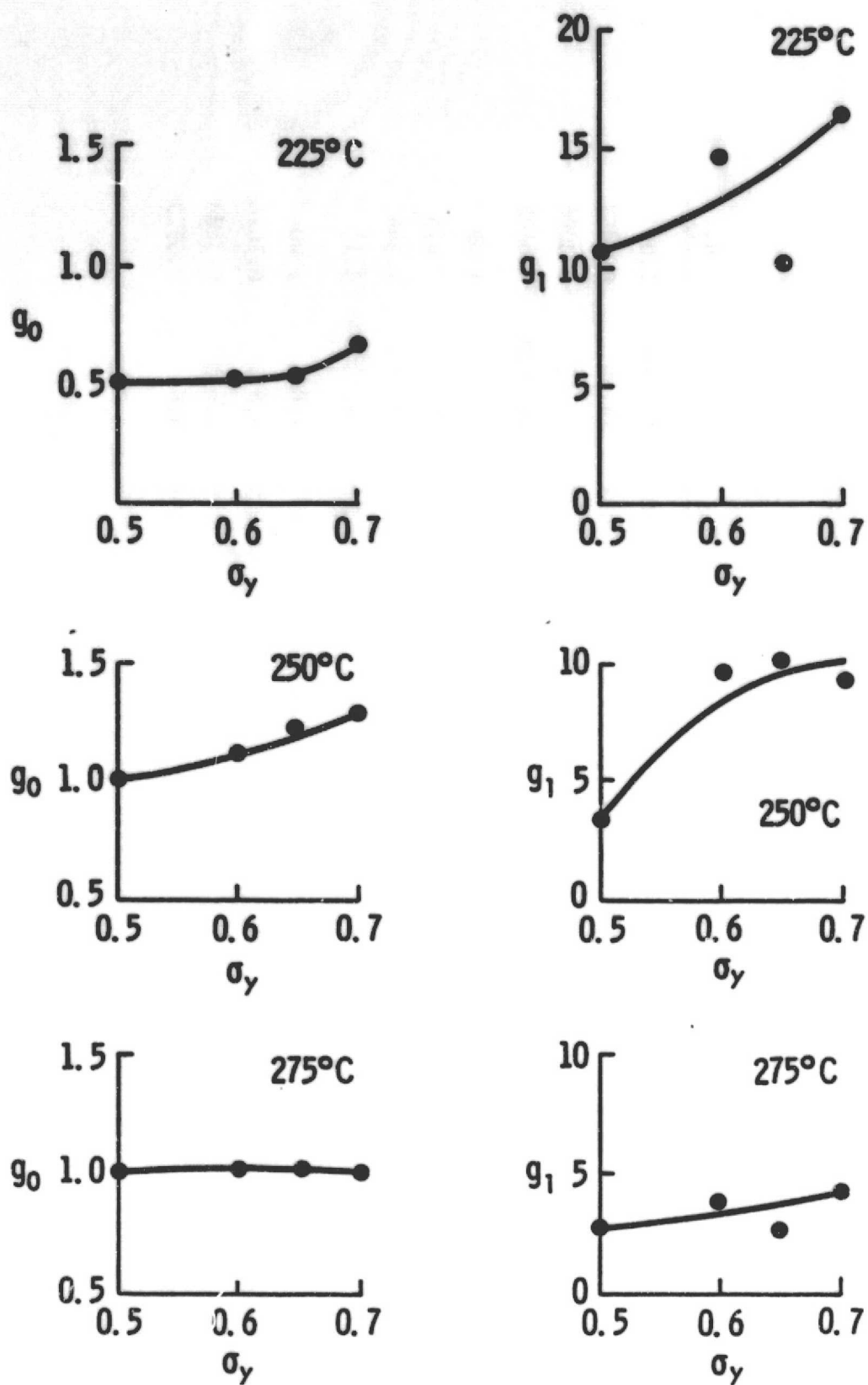


Figure 8. Variation of g_0 and g_1 with stress and temperature in 2024-T4 aluminum.

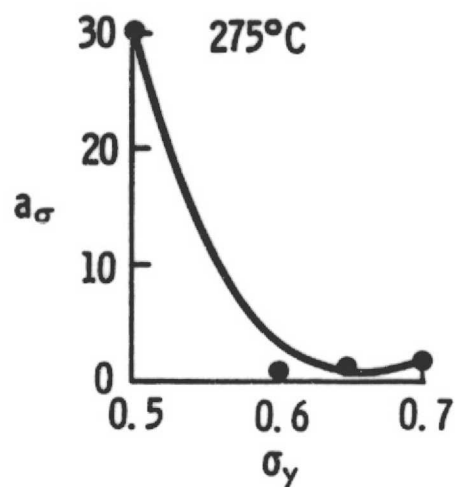
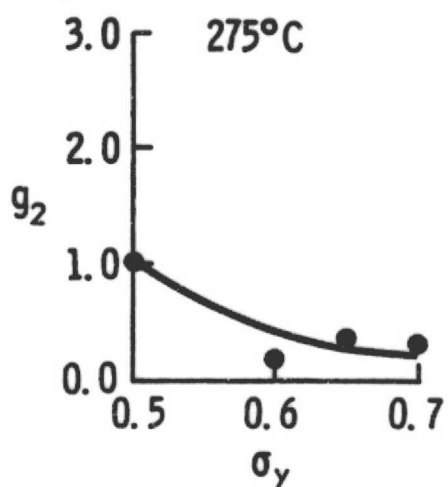
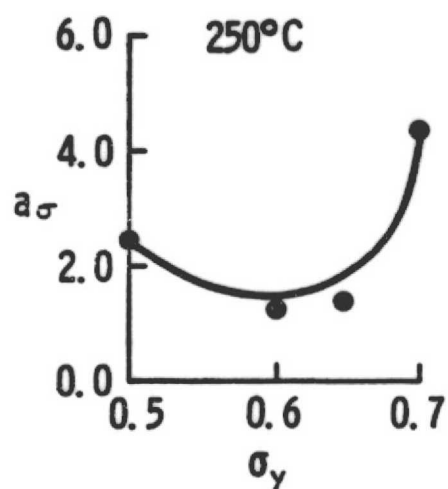
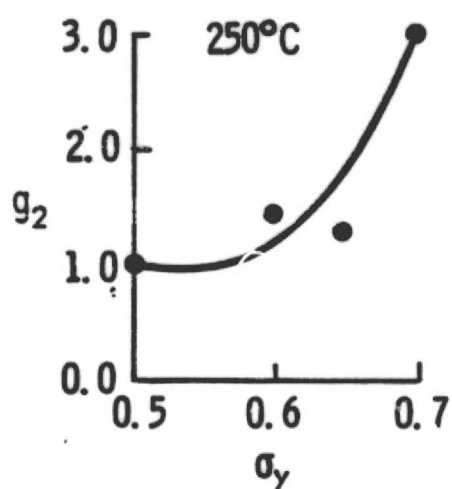
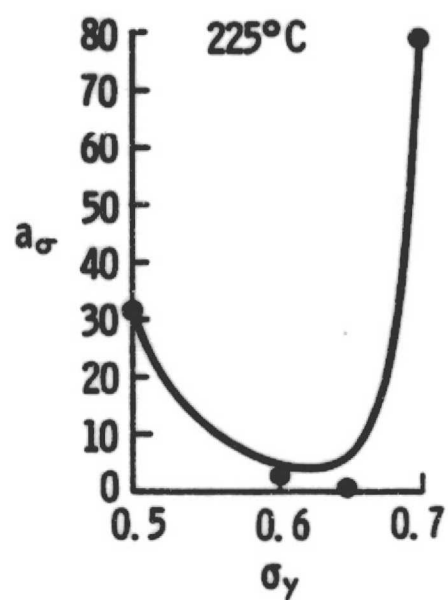
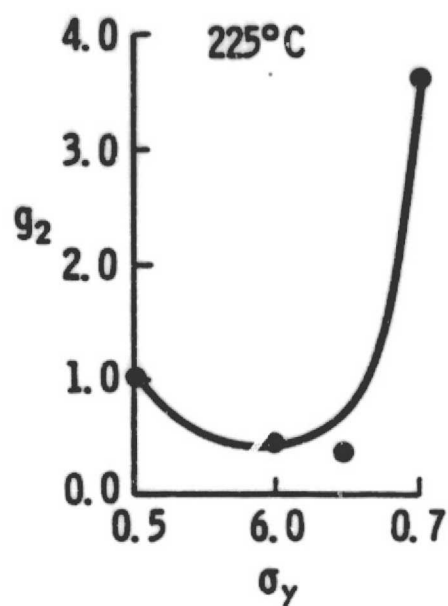


Figure 9. Variation of g_2 and a_σ with stress and temperature in 2024-T4 aluminum.

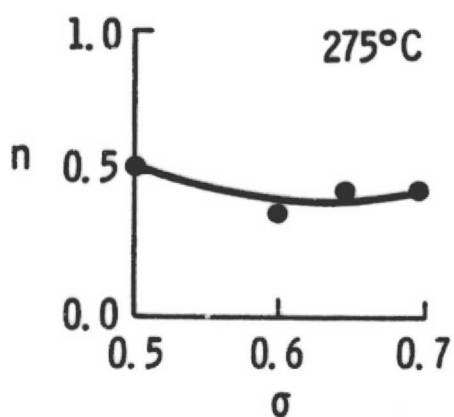
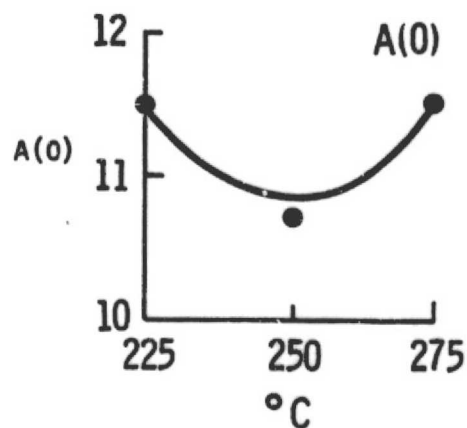
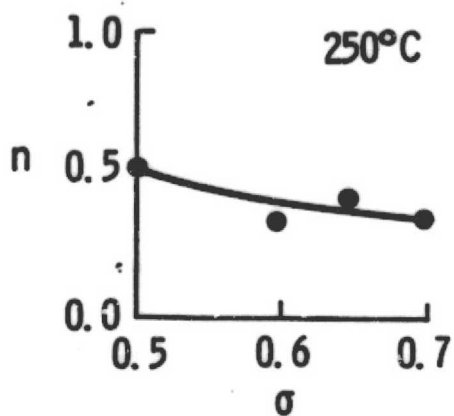
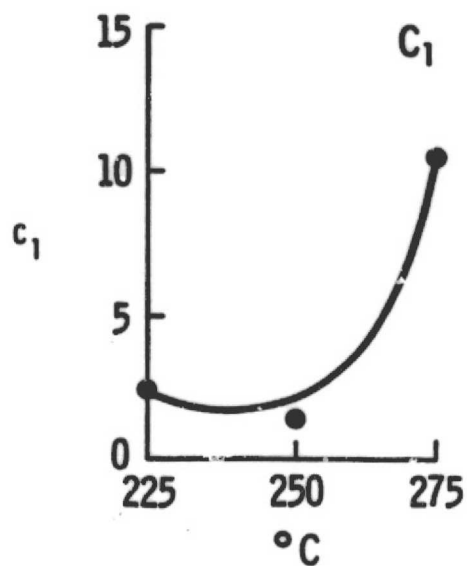
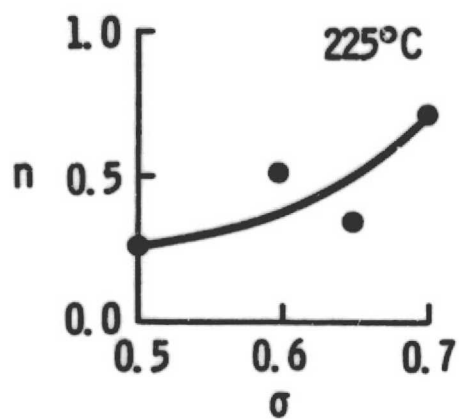


Figure 10. Variation of n with stress and temperature, and variation of C_1 and $A(0)$ with temperature in 2024-T4 aluminum.

Ti-6Al-4V Titanium Alloy

Among the materials examined in this project, Ti-6Al-4V titanium alloy behaved in the most consistent and predictable manner with respect to the constitutive equations that were developed. As a result, more tests were conducted on this alloy than any of the others. The ranges of stress and temperature for these tests are shown schematically in Figure 11; strain-time data for all the tests are given on pages 101 through 148. Table 6 shows the results of data analysis in terms of the resultant constitutive equation parameters for each test condition. Graphs of the influence of stress and temperature on each parameter are given in Figures 12 through 19. The trends are uniform in every case, although some scatter is noted.

Index of Strain-Time Data for Ti-6Al-4V Titanium Alloy

<u>Temp (°C)</u>	<u>Stress (MPa)</u>	<u>%ϵ</u>	<u>Page</u>
440	181	0.3	101
440	241	0.4	103
440	271	0.45	105
440	302	0.5	107
470	151	0.3	109
470	201	0.4	111
470	226	0.45	113
470	252	0.5	115
485	144	0.3	117
485	192	0.4	119
485	216	0.45	121
485	240	0.5	123
500	138	0.3	125
500	184	0.4	127
500	207	0.45	129
500	230	0.5	131
515	133	0.3	133
515	177	0.4	135
515	199	0.45	137
515	222	0.5	139
530	126	0.3	141
530	168	0.4	143
530	189	0.45	145
530	210	0.5	147

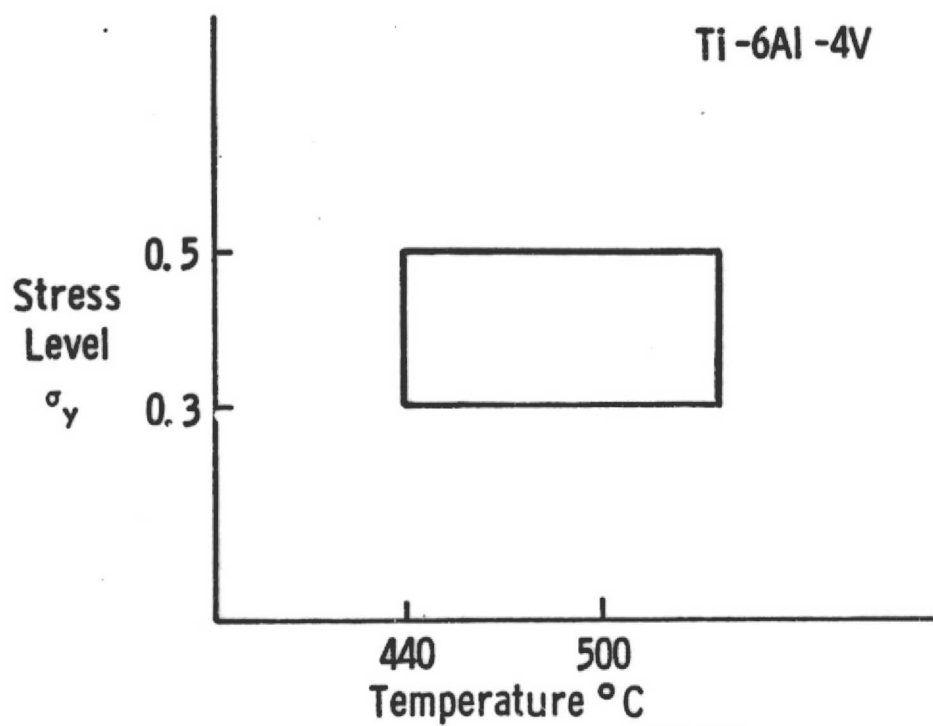


Figure 11. Stress and temperature ranges for creep testing of Ti-6Al-4V titanium alloy.

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.222440	0.00423	2.231576	0.009130	0.070000
2	2.334434	0.00207	2.322140	-0.012294	1.070000
3	2.361670	0.00180	2.372850	-0.011180	2.070000
4	2.441931	0.00167	2.438080	-0.003851	3.070000
5	2.484605	0.00161	2.486780	0.002175	4.070000
6	2.518887	0.00133	2.521380	0.002493	5.070000
7	2.567667	0.00147	2.553990	-0.013677	6.070000
8	2.573262	0.00160	2.572100	-0.001162	7.070000
9	2.595993	0.00132	2.601080	0.005087	8.070000
10	2.616701	0.00123	2.619190	0.002489	9.070000
11	2.635772	0.00118	2.636760	0.000988	10.070000
12	2.653497	0.00112	2.653290	-0.000207	11.070000
13	2.670094	0.00108	2.669910	-0.000184	12.070000
14	2.685728	0.00103	2.685400	-0.000328	13.070000
15	2.700524	0.00104	2.700140	-0.000384	14.070000
16	2.714591	0.00103	2.713380	-0.001211	15.070000
17	2.728012	0.00108	2.727870	-0.000142	16.070000
18	2.740337	0.00112	2.738760	-0.001577	17.070000
19	2.753184	0.00116	2.754680	0.001496	18.070000
20	2.765303	0.00123	2.767720	0.002417	19.070000
21	2.776476	0.00136	2.776420	-0.000056	20.070000
22	2.787517	0.00143	2.786010	-0.001507	21.070000
23	2.798205	0.00153	2.796710	-0.001495	22.070000
24	2.808561	0.00163	2.807480	-0.001081	23.070000
25	2.818612	0.00174	2.814620	-0.003992	24.070000
26	2.828908	0.00183	2.827140	-0.001768	25.070000

SERIAL CORRELATION OF RESIDUALS $\text{SUM}(R(I) \cdot R(I-1)) / \sqrt{(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))}$

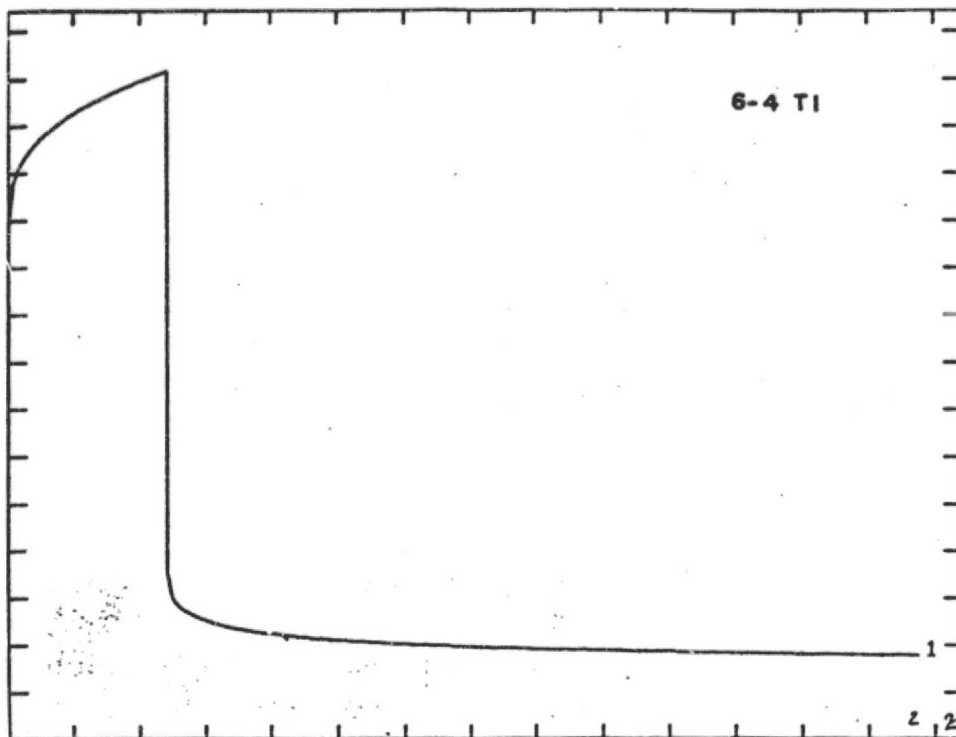
SERIAL CORRELATION OF RESIDUALS ORDERED BY
CASE NUMBER

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	0.450963	0.00325	0.456200	0.005237	0.06150
2	0.603033	0.00221	0.608610	0.005577	0.02410
3	0.752333	0.00175	0.758160	0.005827	0.01625
4	0.9037103	0.00169	0.908910	0.005199	0.01260
5	0.928111	0.00179	0.933660	0.005549	0.02675
6	0.955157	0.00174	0.959910	0.004753	0.04175
7	0.983277	0.00158	0.988360	0.005083	0.05745
8	0.921413	0.00141	0.921680	0.000267	0.04130
9	0.910276	0.00125	0.920310	0.009034	0.03017
10	0.901732	0.00113	0.905740	0.004008	0.04000
11	0.926725	0.00105	0.932680	0.005955	0.05127
12	0.938413	0.00101	0.941230	0.002817	0.03617
13	0.941237	0.00090	0.945610	0.004373	0.02767
14	0.978802	0.00102	0.981830	0.003028	0.03632
15	0.976907	0.00106	0.975310	-0.001597	0.02532
16	0.971465	0.00111	0.970960	-0.000505	0.03645
17	0.965397	0.00117	0.972600	0.007203	0.02152
18	0.969647	0.00123	0.962270	-0.007377	0.03252
19	0.953167	0.00130	0.960320	0.007153	0.02153
20	0.950979	0.00136	0.958640	-0.007661	0.03372
21	0.958404	0.00143	0.955720	-0.002684	0.02377
22	0.956901	0.00149	0.955020	-0.001881	0.02330
23	0.953726	0.00155	0.952120	-0.001606	0.02149

SERIAL CORRELATION OF RESIDUALS $\text{SUM}(R(I) \cdot R(I-1)) / \sqrt{(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))}$

SERIAL CORRELATION OF RESIDUALS ORDERED BY
CASE NUMBER

2



PLOT NUMBER										
6-4 T1 (0.3) YIELD TEMPERATURE = 440 C										
TIME BASE										
TOTAL TIME 274.0 MIN										
RECOVERY AT 45.2 MIN										
INCREMENT OF TIME 1.417 MIN										
INPUT VARIABLES										
LINE	STRESS	CO	CT	GO	GT	YGT	EX	LEND	YUNE	ENT
NUMBER (PSI)										
1	23407.3	4.072E-03	0.4184E-08	1.0000	1.6693	1.0000	0.34081	0.29945E-03	40.18000	0.73526
0.300E-02										
0.280E-02										
0.260E-02										
0.240E-02										
0.220E-02										
0.200E-02										
0.180E-02										
0.160E-02										
0.140E-02										
0.120E-02										
0.100E-02										
0.800E-03										
0.600E-03										
0.400E-03										
0.200E-03										
0.										
20.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	3.271107	0.00254	3.275007	0.003900	2.166700
2	3.026458	0.00384	3.022300	-0.004158	1.166700
3	3.022568	0.00384	3.022300	-0.000268	2.166700
4	3.154021	0.00279	3.150700	-0.003321	3.166700
5	3.202343	0.00269	3.202300	-0.000043	4.166700
6	3.241100	0.00264	3.235400	-0.005700	5.166700
7	3.275108	0.00262	3.272200	-0.002908	6.166700
8	3.305612	0.00254	3.300700	-0.004912	7.166700
9	3.333370	0.00254	3.333300	-0.000070	8.166700
10	3.362809	0.00250	3.362200	-0.000609	10.166700
11	3.424677	0.00232	3.422300	-0.002377	12.166700
12	3.465449	0.00232	3.464400	-0.001049	14.166700
13	3.501129	0.00225	3.511200	0.010071	16.166700
14	3.534008	0.00218	3.539000	0.004992	18.166700
15	3.564607	0.00217	3.574600	0.010000	20.166700
16	3.593292	0.00210	3.603200	0.010000	22.166700
17	3.622161	0.00209	3.623300	0.001139	24.166700
18	3.645971	0.00212	3.650500	0.004529	26.166700
19	3.670356	0.00213	3.671500	0.001144	28.166700
20	3.693661	0.00206	3.693800	0.000139	30.166700
21	3.715062	0.00217	3.720500	0.005438	32.166700
22	3.737976	0.00206	3.747900	0.010000	34.166700
23	3.762085	0.00201	3.763300	0.001215	36.166700
24	3.833733	0.00341	3.838400	0.004667	44.166700
25	3.876634	0.00306	3.882200	0.005566	49.166700
26	3.899109	0.00423	3.897300	-0.001809	51.166700

SERIAL CORRELATION OF RESIDUALS=SUM(R(I)*R(I-1))/SQRT(SUM(R(I)**2)*SUM(R(I-1)**2))

SERIAL CORRELATION 0.55033 RESIDUALS ORDERED ON CASE NUMBER

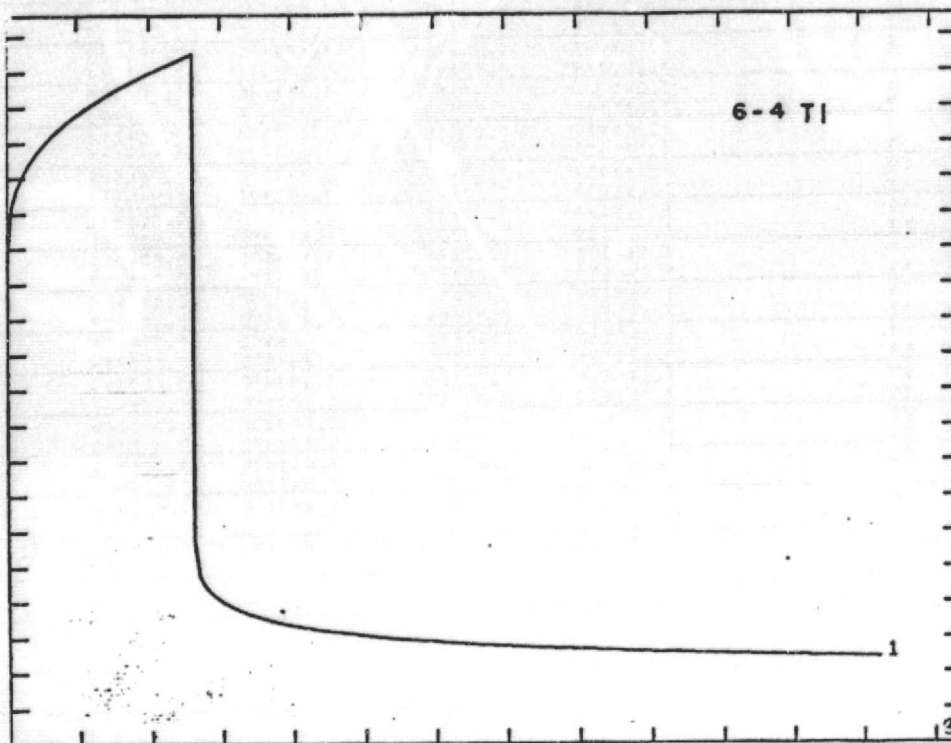
3

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.067338	0.00385	1.065400	-0.001938	0.001900
2	1.045635	0.00349	1.044600	-0.001035	0.003800
3	0.959652	0.00233	0.961000	0.001348	0.023000
4	0.917952	0.00198	0.923400	0.005448	0.042300
5	0.888621	0.00184	0.891400	0.002779	0.061500
6	0.865401	0.00179	0.863500	-0.001901	0.080500
7	0.829628	0.00179	0.831500	0.001872	0.119300
8	0.802166	0.00183	0.795300	-0.006866	0.137800
9	0.779803	0.00187	0.778500	-0.001303	0.196300
10	0.752482	0.00190	0.757600	0.005118	0.254100
11	0.723698	0.00191	0.727000	0.003302	0.331100
12	0.701626	0.00189	0.696400	-0.005226	0.404400
13	0.682296	0.00185	0.688500	0.006204	0.481400
14	0.651610	0.00175	0.647600	-0.004010	0.633500
15	0.627988	0.00165	0.636500	0.008512	0.789600
16	0.609026	0.00157	0.615800	0.006774	0.943800
17	0.593326	0.00152	0.604500	0.011174	1.097700
18	0.580049	0.00150	0.582200	0.002151	1.251800
19	0.568633	0.00151	0.571000	0.002367	1.405800
20	0.554746	0.00157	0.546000	-0.008746	1.636900
21	0.542061	0.00167	0.529300	-0.012761	1.868000
22	0.528694	0.00183	0.527900	-0.000794	2.176000
23	0.517644	0.00200	0.522300	0.004656	2.484000
24	0.508308	0.00218	0.509800	0.001492	2.792400
25	0.500319	0.00235	0.507000	0.006681	3.107100
26	0.493354	0.00251	0.493000	-0.000354	3.438700
27	0.487242	0.00266	0.481900	-0.005342	3.750600

SERIAL CORRELATION OF RESIDUALS=SUM(R(I)*R(I-1))/SQRT(SUM(R(I)**2)*SUM(R(I-1)**2))

SERIAL CORRELATION 0.38900 RESIDUALS ORDERED ON CASE NUMBER

3



PLOT NUMBER										
6-4 TI 0.4 YIELD TEMPERATURE= 440 C										
TIME BASE										
TOTAL TIME 240.0 MIN										
RECOVERY AT 32.0 MIN										
INCREMENT OF TIME 1.000 MIN										
INPUT VARIABLES										
LINE NUMBER	STRESS (PSI)	C0	C1	C2	C3	C4	C5	C6	C7	C8
1	31209.37936E-03	0.4184E-08	0.9464	1.5150	1.3580	0.34759	0.36391E-03	51.92667	0.79032	
2	0.400E-02									
3	0.350E-02									
4	0.300E-02									
5	0.250E-02									
6	0.200E-02									
7	0.150E-02									
8	0.100E-02									
9	0.050E-02									
10	0.000E-02									
11	0.000E-02									
12	0.000E-02									
13	0.000E-02									
14	0.000E-02									
15	0.000E-02									
16	0.000E-02									
17	0.000E-02									
18	0.000E-02									
19	0.000E-02									
20	0.000E-02									
21	0.000E-02									
22	0.000E-02									
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27	0.000E-02									
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29	0.000E-02									
30	0.000E-02									
31	0.000E-02									
32	0.000E-02									
33	0.000E-02									
34	0.000E-02									
35	0.000E-02									
36	0.000E-02									
37	0.000E-02									
38	0.000E-02									
39	0.000E-02									
40	0.000E-02									
41	0.000E-02									
42	0.000E-02									
43	0.000E-02									
44	0.000E-02									
45	0.000E-02									
46	0.000E-02									
47	0.000E-02									
48	0.000E-02									
49	0.000E-02									
50	0.000E-02									
51	0.000E-02									
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79	0.000E-02									
80	0.000E-02									
81	0.000E-02									
82	0.000E-02									
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85	0.000E-02									
86	0.000E-02									
87	0.000E-02									
88	0.000E-02									
89	0.000E-02									
90	0.000E-02									
91	0.000E-02									
92	0.000E-02									
93	0.000E-02									
94	0.000E-02									
95	0.000E-02									
96	0.000E-02									
97	0.000E-02									
98	0.000E-02									
99	0.000E-02									
100	0.000E-02									

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.931662	0.00355	2.866910	-0.032772	0.100000
2	3.106003	0.00463	3.073070	-0.032938	1.100000
3	3.264705	0.00423	3.259310	-0.005395	3.100000
4	3.364428	0.00456	3.373930	0.009502	5.100000
5	3.441206	0.00425	3.452720	0.011512	7.100000
6	3.505019	0.00395	3.513610	0.008591	9.100000
7	3.560321	0.00367	3.560170	-0.000151	11.100000
8	3.609520	0.00342	3.613900	0.004380	13.100000
9	3.654083	0.00320	3.653300	-0.000783	15.100000
10	3.694996	0.00302	3.692690	-0.002306	17.100000
11	3.732929	0.00256	3.732090	-0.000839	19.100000
12	3.768381	0.00279	3.775070	0.006689	21.100000
13	3.801723	0.00274	3.814470	0.012742	23.100000
14	3.833264	0.00274	3.850290	0.017026	25.100000
15	3.863220	0.00278	3.873930	0.010710	27.100000
16	3.891733	0.00236	3.896650	0.004917	29.100000
17	3.919107	0.00298	3.930520	0.011413	31.100000
18	3.945322	0.00311	3.954150	0.008828	33.100000
19	3.970536	0.00328	3.975640	0.005104	35.100000
20	3.994840	0.00346	3.997130	0.002290	37.100000
21	4.018313	0.00365	4.011460	-0.006853	39.100000
22	4.041026	0.00335	4.032950	-0.008076	41.100000
23	4.053037	0.00407	4.050860	-0.002177	43.100000
24	4.064400	0.00429	4.072350	0.007950	45.100000
25	4.075161	0.00451	4.090260	0.015100	47.100000
26	4.086184	0.00452	4.092410	0.006226	49.100000

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.79841 RESIDUALS ORDERED ON CASE NUMBER

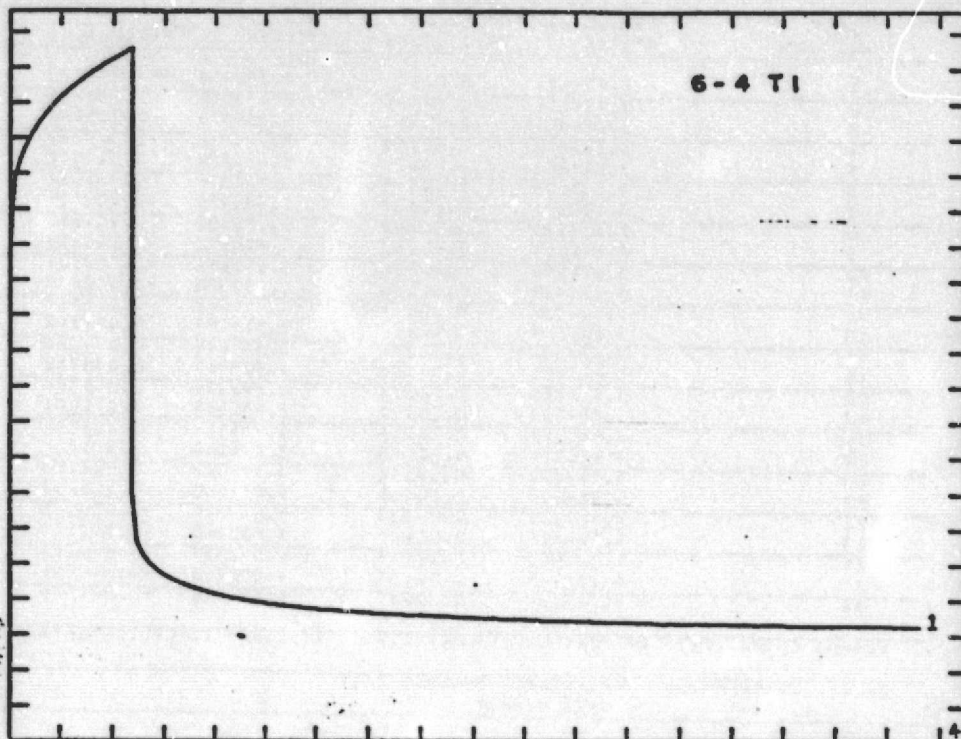
4

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.303324	0.00601	1.310890	0.007566	0.003180
2	1.199899	0.00405	1.199860	-0.000039	0.024360
3	1.071955	0.00312	1.067360	-0.004595	0.109110
4	0.998526	0.00320	0.984960	-0.013566	0.215040
5	0.930571	0.00325	0.920490	-0.010081	0.384530
6	0.855847	0.00297	0.856020	0.000173	0.723520
7	0.812461	0.00259	0.813060	0.000599	1.062500
8	0.783065	0.00226	0.791550	0.008485	1.401480
9	0.761456	0.00201	0.775790	0.014334	1.740470
10	0.744729	0.00185	0.754300	0.009571	2.079450
11	0.731303	0.00176	0.737820	0.006517	2.418430
12	0.720232	0.00175	0.730660	0.010428	2.757420
13	0.710911	0.00175	0.716330	0.005419	3.096400
14	0.702930	0.00180	0.702010	-0.000920	3.435380
15	0.696003	0.00187	0.698420	0.002417	3.774360
16	0.689922	0.00196	0.687680	-0.002242	4.113350
17	0.684531	0.00204	0.680520	-0.004011	4.452330
18	0.679711	0.00213	0.676930	-0.002781	4.791310
19	0.675372	0.00222	0.666190	-0.009182	5.130300
20	0.671440	0.00231	0.664190	-0.007250	5.469280
21	0.667857	0.00240	0.664760	-0.003097	5.808260
22	0.664575	0.00248	0.661170	-0.003405	6.147250
23	0.661738	0.00255	0.655440	-0.006298	6.486040

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.72612 RESIDUALS ORDERED ON CASE NUMBER

4



PLOT NUMBER																	
6-4 T1 GAS YIELD/TEMPERATURE= 463 C																	
TIME BASE																	
TOTAL TIME 352.1 MIN																	
RECOVERY AT 47.2 MIN																	
INCREMENT OF TIME 1.015 MIN																	
INPUT VARIABLES																	
LINE	STRESS	C2	C1	C0	C1	C2	C3	CENS	TIME	ENT							
NUMBER	(PSI)																
1	35100.7	0.8360E-03	0.4184E-08	0.8531	1.6208	1.3676	2.31736	0.56804E-03	47.20003	2.55512							
0.400E-02																	
0.380E-02																	
0.360E-02																	
0.340E-02																	
0.320E-02																	
0.300E-02																	
0.280E-02																	
0.260E-02																	
0.240E-02																	
0.220E-02																	
0.200E-02																	
0.180E-02																	
0.160E-02																	
0.140E-02																	
0.120E-02																	
0.100E-02																	
0.800E-03																	
0.400E-03																	
0.100E-03																	
0.200E-03																	
0.																	
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0	320.0	340.0	360.0

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	3.244719	0.00313	3.242600	-0.002119	0.100000
2	3.283401	0.00271	3.281600	-0.001801	0.183300
3	3.435863	0.00182	3.441100	0.005237	0.783300
4	3.570337	0.00165	3.573400	0.003063	1.783300
5	3.664366	0.00168	3.668100	0.003734	2.783300
6	3.739943	0.00173	3.735500	-0.004443	3.783300
7	3.804445	0.00176	3.810800	0.006355	4.783300
8	4.003489	0.00176	3.997600	-0.005889	5.783300
9	4.133581	0.00166	4.150600	-0.002981	12.783300
10	4.277848	0.00152	4.280300	0.002452	16.783300
11	4.385616	0.00142	4.384000	-0.001613	20.783300
12	4.431716	0.00137	4.474800	-0.008916	24.783300
13	4.569037	0.00140	4.565700	-0.003337	28.783300
14	4.649432	0.00151	4.656300	0.007048	32.783300
15	4.724261	0.00169	4.727900	0.003639	36.783300
16	4.794408	0.00192	4.792600	-0.001808	40.783300
17	4.860600	0.00218	4.864000	0.003401	44.783300
18	4.868624	0.00221	4.866600	-0.002024	49.283300

SERIAL CORRELATION OF RESIDUALS=SUM(R(I)*R(I-1))/SORT(SUM(R(I)**2)*SUM(R(I-1)**2))

SERIAL CORRELATION
-0.13682

RESIDUALS ORDERED ON
CASE NUMBER

5

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.414677	0.00742	1.427800	0.011323	0.022000
2	1.425708	0.00383	1.413800	-0.011908	0.110400
3	1.332743	0.00308	1.321700	-0.011043	0.198700
4	1.269157	0.00292	1.262100	-0.007057	0.287100
5	1.220939	0.00289	1.219300	-0.001639	0.375400
6	1.182250	0.00286	1.182900	0.000650	0.463700
7	1.150071	0.00281	1.154400	0.004329	0.552100
8	1.122713	0.00274	1.128400	0.005687	0.640400
9	1.078133	0.00257	1.086900	0.008767	0.817100
10	1.042982	0.00232	1.048000	0.005018	0.893700
11	1.014246	0.00221	1.009200	-0.005046	1.170600
12	0.990170	0.00206	1.002600	0.012430	1.347100
13	0.969616	0.00195	0.973400	0.003784	1.523700
14	0.951778	0.00189	0.962500	0.010722	1.700400
15	0.936114	0.00187	0.935200	-0.000914	1.877100
16	0.922222	0.00188	0.918300	-0.003922	2.053700
17	0.909780	0.00193	0.911900	0.002120	2.230400
18	0.898560	0.00200	0.896200	-0.002360	2.407100
19	0.888379	0.00209	0.883300	-0.005079	2.583200
20	0.879080	0.00219	0.872900	-0.006180	2.760400
21	0.870546	0.00230	0.853400	-0.017146	2.937100
22	0.862684	0.00242	0.848300	-0.014384	3.113700
23	0.855603	0.00254	0.832100	-0.023503	3.290400
24	0.848640	0.00266	0.848300	-0.000340	3.467100
25	0.842340	0.00278	0.844600	0.002260	3.643700
26	0.836446	0.00290	0.844400	0.007954	3.820400
27	0.830922	0.00301	0.844400	0.013478	3.997100

SERIAL CORRELATION OF RESIDUALS=SUM(R(I)*R(I-1))/SORT(SUM(R(I)**2)*SUM(R(I-1)**2))

SERIAL CORRELATION
0.49316

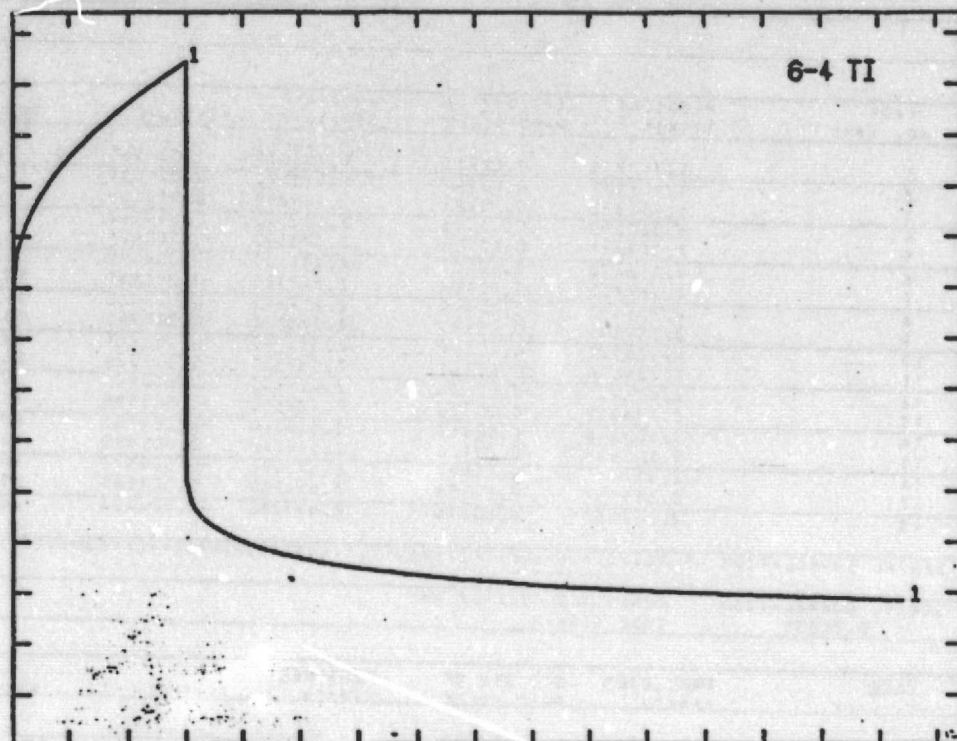
RESIDUALS ORDERED ON
CASE NUMBER

5

ORIGINAL PAGE IS
OF POOR QUALITY

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.317715	0.00910	1.703150	-0.024565	0.100530
2	1.401111	0.00540	1.922170	0.021559	1.000000
3	1.350352	0.00645	1.304220	0.014364	2.000000
4	2.320513	0.00603	2.335570	0.015057	4.000000
5	2.073611	0.00483	2.073340	-0.000271	6.000000
6	2.116472	0.00467	2.110360	-0.006112	8.000000
7	2.157709	0.00406	2.167320	0.009611	10.000000
8	2.225530	0.00349	2.217570	-0.007960	14.000000
9	2.284015	0.00361	2.275320	-0.008695	18.000000
10	2.336121	0.00361	2.335170	-0.000951	22.000000
11	2.383384	0.00361	2.382560	-0.000824	26.000000
12	2.427426	0.00333	2.429650	0.002224	30.000000
13	2.478209	0.00338	2.476650	-0.001559	35.000000
14	2.525360	0.00363	2.523690	-0.001670	40.000000
15	2.569040	0.00404	2.570740	0.001700	45.000000
16	2.611447	0.00487	2.611070	-0.000377	50.000000
17	2.651157	0.00530	2.654750	0.003593	55.000000
18	2.689057	0.00616	2.695040	0.005983	60.000000
SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I)^2) \cdot \sum(R(I-1)^2))}}$					
SERIAL CORRELATION		RESIDUALS ORDERED ON			
0.24531		CASE NUMBER			

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	0.847615	0.00171	0.846630	-0.000985	0.101601
2	0.823256	0.00345	0.826670	0.003414	0.251243
3	0.813603	0.00257	0.819870	0.006267	0.317913
4	0.786626	0.00223	0.791850	0.005224	0.384363
5	0.772172	0.00202	0.772980	0.000808	0.450923
6	0.759310	0.00195	0.759430	0.000120	0.517473
7	0.747807	0.00185	0.747660	-0.000147	0.584033
8	0.737592	0.00195	0.732580	-0.005012	0.650590
9	0.728228	0.00202	0.724510	-0.003718	0.717163
10	0.719646	0.00205	0.712410	-0.007236	0.783693
11	0.711741	0.00202	0.703330	-0.008411	0.850263
12	0.704421	0.00200	0.698970	-0.005451	0.916810
13	0.697613	0.00200	0.692260	-0.005353	0.983363
14	0.691420	0.00201	0.685530	-0.005890	1.049913
15	0.685227	0.00191	0.678880	-0.006347	1.116463
16	0.679020	0.00181	0.672290	-0.006730	1.183013
17	0.672781	0.00176	0.665570	-0.007211	1.249563
18	0.667984	0.00172	0.661760	-0.006224	1.316113
19	0.663697	0.00173	0.657480	-0.006217	1.382663
20	0.659951	0.00183	0.653200	-0.006751	1.449213
21	0.656212	0.00180	0.649880	-0.006332	1.515763
22	0.652474	0.00204	0.645520	-0.006954	1.582313
23	0.648735	0.00222	0.641220	-0.007515	1.648863
24	0.644993	0.00237	0.637660	-0.007333	1.715413
25	0.641254	0.00256	0.633800	-0.007454	1.781963
26	0.637512	0.00275	0.629940	-0.007572	1.848513
27	0.633769	0.00322	0.626080	-0.007689	1.915063
SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I)^2) \cdot \sum(R(I-1)^2))}}$					
SERIAL CORRELATION		RESIDUALS ORDERED ON			
0.63564		CASE NUMBER			



PLOT NUMBER									
6-4 TI 0.3 YIELD TEMPERATURE= 470 C									
TIME BASE									
TOTAL TIME 300.1 MIN									
RECOVERY AT 60.0 MIN									
INCREMENT OF TIME 1.500 MIN									
INPUT VARIABLES									
LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7
NUMBER	(PSI)								
1	21750.0	0.447298	-0.30	321038	-0.01	000001	409761	000000	488090
0.280E-02									
0.240E-02									
0.220E-02									
0.200E-02									
0.180E-02									
0.160E-02									
0.140E-02									
0.120E-02									
0.100E-02									
0.800E-03									
0.600E-03									
0.400E-03									
0.200E-03									
0.									
28.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
	220.0	240.0	260.0	280.0	300.0	320.0			

ORIGINAL PAGE IS
OF POOR QUALITY

CASE NO.	PREDICTED STRAIN	STD DEV OF PRED VALUE	UNBIASED STRAIN	RESIDUAL	RTIME
1	2.271214	0.00124	2.266137	-0.005077	1.000000
2	2.267819	0.00170	2.260547	-0.007272	2.000000
3	2.264377	0.00154	2.258627	-0.005750	3.000000
4	2.259304	0.00137	2.254296	-0.005008	4.000000
5	2.254734	0.00112	2.249717	-0.005017	5.000000
6	2.251117	0.00103	2.246750	-0.004367	6.000000
7	2.246459	0.00088	2.242022	-0.004437	7.000000
8	2.240617	0.00077	2.236790	-0.003827	8.000000
9	2.234114	0.00064	2.230287	-0.003827	9.000000
10	2.225062	0.00053	2.221137	-0.003925	10.000000
11	2.215524	0.00044	2.211577	-0.003947	11.000000
12	2.205881	0.00034	2.201940	-0.003941	12.000000
13	2.195226	0.00028	2.191287	-0.003939	13.000000
14	2.183662	0.00021	2.179100	-0.004562	14.000000
15	2.171118	0.00014	2.166527	-0.004591	15.000000
16	2.157699	0.00011	2.153100	-0.004599	16.000000
17	2.143280	0.00008	2.138827	-0.004453	17.000000
18	2.127914	0.00005	2.123640	-0.004274	18.000000
19	2.111611	0.00003	2.107367	-0.004244	19.000000
20	2.094474	0.00002	2.089190	-0.005284	20.000000
21	2.076527	0.00001	2.071250	-0.005277	21.000000
22	2.057869	0.00000	2.052590	-0.005279	22.000000
23	2.038489	0.00000	2.033210	-0.005279	23.000000
24	2.018375	0.00000	2.013100	-0.005275	24.000000
25	2.000000	0.00000	1.994725	-0.005275	25.000000
26	1.981625	0.00000	1.976350	-0.005275	26.000000
27	1.963250	0.00000	1.957975	-0.005275	27.000000
28	1.944875	0.00000	1.939600	-0.005275	28.000000
29	1.926500	0.00000	1.921225	-0.005275	29.000000
30	1.908125	0.00000	1.902850	-0.005275	30.000000
31	1.889750	0.00000	1.884475	-0.005275	31.000000
32	1.871375	0.00000	1.866100	-0.005275	32.000000
33	1.853000	0.00000	1.847725	-0.005275	33.000000
34	1.834625	0.00000	1.829350	-0.005275	34.000000
35	1.816250	0.00000	1.810975	-0.005275	35.000000

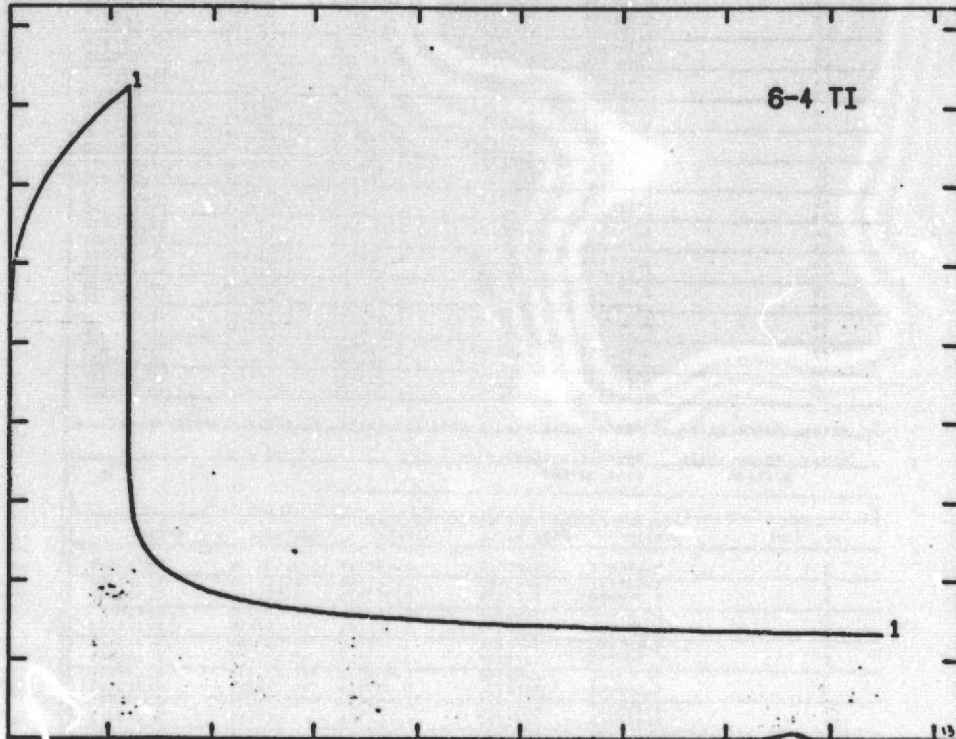
SERIAL CORRELATION OF RESIDUALS = $SUM((Y_i - \bar{Y})(Y_{i-1} - \bar{Y})) / (SUM((Y_i - \bar{Y})^2) * SUM((Y_{i-1} - \bar{Y})^2))^{0.5}$

SERIAL CORRELATION OF RESIDUALS ORDERED BY
0.41294 CASE NUMBER

CASE NO.	PREDICTED STRAIN	STD DEV OF PRED VALUE	UNBIASED STRAIN	RESIDUAL	RTIME
1	1.449412	0.00114	1.449233	0.000179	0.019668
2	1.377692	0.00073	1.377133	0.000559	0.030313
3	1.349982	0.00134	1.349702	0.000280	0.052173
4	1.313063	0.00232	1.312723	0.000340	0.068767
5	1.274309	0.00299	1.273249	0.001060	0.089112
6	1.237903	0.00277	1.236863	0.001040	0.111477
7	1.226799	0.00295	1.225723	0.001076	0.117063
8	1.205306	0.00263	1.204250	0.001056	0.134213
9	1.186669	0.00236	1.185633	0.001036	0.160963
10	1.167907	0.00223	1.166877	0.001030	0.174673
11	1.148995	0.00225	1.147960	0.001035	0.202613
12	1.127777	0.00226	1.126743	0.001034	0.209163
13	1.097223	0.00231	1.096196	0.001027	0.247073
14	1.069813	0.00236	1.068768	0.001045	0.230913
15	1.042168	0.00231	1.041170	0.000998	0.263263
16	1.017002	0.00223	1.015933	0.001069	0.270673
17	1.003206	0.00237	1.002099	0.001107	0.280613
18	0.990636	0.00235	0.989577	0.001059	0.282103
19	0.979783	0.00231	0.978719	0.001064	0.287003
20	0.969713	0.00226	0.968650	0.001063	0.292673
21	0.960336	0.00220	0.959260	0.001076	0.297063
22	0.951309	0.00215	0.950225	0.001084	0.301113
23	0.942485	0.00210	0.941390	0.001095	0.304873
24	0.933902	0.00203	0.932793	0.001109	0.308303
25	0.925578	0.00196	0.924460	0.001118	0.311403
26	0.917428	0.00189	0.916300	0.001128	0.314163
27	0.909464	0.00182	0.908325	0.001139	0.316583
28	0.901686	0.00175	0.900537	0.001149	0.318663
29	0.894096	0.00168	0.892937	0.001159	0.320403
30	0.886696	0.00161	0.885527	0.001169	0.321813
31	0.879486	0.00154	0.878307	0.001179	0.322913
32	0.872466	0.00147	0.871277	0.001189	0.323713
33	0.865636	0.00140	0.864437	0.001199	0.324213
34	0.858996	0.00133	0.857787	0.001209	0.324413
35	0.852546	0.00126	0.851327	0.001219	0.324313
36	0.846286	0.00119	0.845057	0.001229	0.323913
37	0.840216	0.00112	0.838977	0.001239	0.323213
38	0.834336	0.00105	0.833087	0.001249	0.322213
39	0.828646	0.00098	0.827387	0.001259	0.320913
40	0.823146	0.00091	0.821877	0.001269	0.319213
41	0.817836	0.00084	0.816557	0.001279	0.317113
42	0.812716	0.00077	0.811427	0.001289	0.314613
43	0.807786	0.00070	0.806487	0.001299	0.311713
44	0.803046	0.00063	0.801737	0.001309	0.308413
45	0.798486	0.00056	0.797167	0.001319	0.304713
46	0.794106	0.00049	0.792777	0.001329	0.300613
47	0.789906	0.00042	0.788567	0.001339	0.296113
48	0.785886	0.00035	0.784537	0.001349	0.291213
49	0.782046	0.00028	0.780687	0.001359	0.285913
50	0.778386	0.00021	0.776917	0.001369	0.280213

SERIAL CORRELATION OF RESIDUALS = $SUM((Y_i - \bar{Y})(Y_{i-1} - \bar{Y})) / (SUM((Y_i - \bar{Y})^2) * SUM((Y_{i-1} - \bar{Y})^2))^{0.5}$

SERIAL CORRELATION OF RESIDUALS ORDERED BY
0.41294 CASE NUMBER



PLOT NUMBER
6-4 TI 0.4 YIELD TEMPERATURE 470 C

TIME BASE
TOTAL TIME 424.5 MIN
RECOVERY AT 99.0 MIN
INCREMENT OF TIME 2.270 MIN

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	TIME	END
1	29000.0	0.11939E-02	0.32303E-01	0.09501E-02	0.29602E-01	0.76100E-01	0.41937E-01	0.33568E-03	0.10000E-01	0.10000E-01	0.10000E-01	0.10000E-01	0.10000E-01
0.450E-02													
0.400E-02													
0.350E-02													
0.300E-02													
0.250E-02													
0.200E-02													
0.150E-02													
0.100E-02													
0.500E-03													
0.													
50.0	100.0	150.0	200.0	250.0	300.0	350.0	400.0	450.0					

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		3.021179	0.00466	3.025600	-0.004421	0.100000
2		3.204430	0.00267	3.255610	-0.051180	1.100000
3		3.374222	0.00274	3.377470	-0.003248	2.100000
4		3.561944	0.00335	3.531390	0.030554	3.100000
5		3.629936	0.00201	3.640050	-0.010114	4.100000
6		3.717569	0.00164	3.725430	-0.007861	5.100000
7		3.827912	0.00194	3.826520	0.001392	11.100000
8		3.921771	0.00176	3.918730	0.003041	16.100000
9		4.002990	0.00177	3.998060	0.004930	17.100000
10		4.075537	0.00167	4.063950	0.011587	20.100000
11		4.143333	0.00158	4.139310	0.004023	23.100000
12		4.211550	0.00150	4.197480	0.014070	26.100000
13		4.263999	0.00143	4.259150	0.004849	29.100000
14		4.311527	0.00141	4.311370	0.000157	32.100000
15		4.369762	0.00140	4.367310	0.002452	35.100000
16		4.418000	0.00143	4.426930	-0.008930	38.100000
17		4.466163	0.00149	4.471740	-0.005577	41.100000
18		4.504712	0.00155	4.509030	-0.004318	44.100000
19		4.552464	0.00170	4.550060	0.002404	47.100000
20		4.593548	0.00183	4.594810	-0.001262	50.100000
21		4.633268	0.00199	4.632110	0.001158	53.100000
22		4.671506	0.00215	4.673130	-0.001624	56.100000
23		4.708719	0.00233	4.714160	-0.005441	59.100000
24		4.723265	0.00240	4.725350	-0.002085	60.300000

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-R(I-1))}{\sqrt{(\sum(R(I))^2+\sum(R(I-1))^2)}}$

SERIAL CORRELATION 0.65288 RESIDUALS ORDERED ON CASE NUMBER

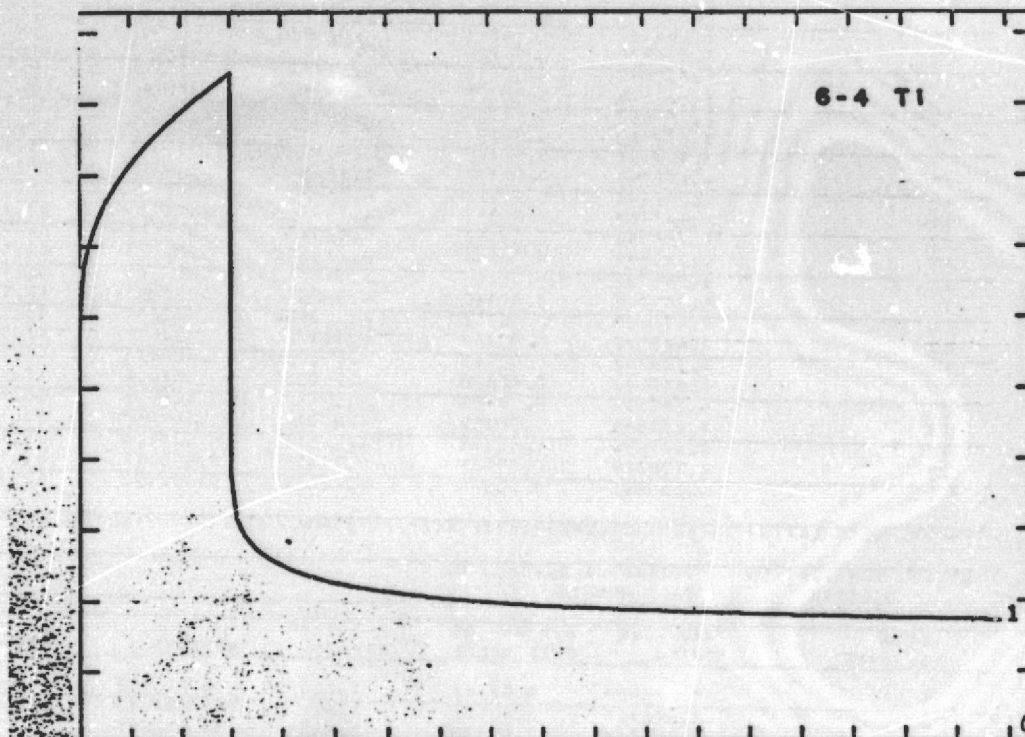
6

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1		1.748367	0.00602	1.760350	0.011983	0.003320
2		1.526545	0.00403	1.622360	-0.095815	0.019900
3		1.565268	0.00338	1.555220	0.010048	0.036480
4		1.521270	0.00309	1.510470	0.010800	0.053070
5		1.657137	0.00294	1.654530	0.002607	0.066240
6		1.355616	0.00313	1.361290	-0.005674	0.169150
7		1.290003	0.00330	1.297890	-0.007887	0.252070
8		1.225500	0.00334	1.234480	-0.008980	0.368150
9		1.132832	0.00310	1.141240	-0.008408	0.633500
10		1.075287	0.00275	1.070380	0.004907	0.896840
11		1.034871	0.00244	1.029360	0.005511	1.164180
12		1.044449	0.00220	0.994300	0.050149	1.429520
13		0.930486	0.00205	0.977140	-0.046654	1.694860
14		0.960990	0.00198	0.973410	-0.012420	1.960200
15		0.944736	0.00196	0.924930	0.019806	2.225540
16		0.930925	0.00199	0.924930	0.005995	2.490830
17		0.919008	0.00206	0.924930	0.005922	2.756220
18		0.938593	0.00214	0.917470	0.021123	3.021560
19		0.900486	0.00223	0.908520	-0.008034	3.253730
20		0.892172	0.00233	0.901060	-0.008888	3.519070
21		0.884712	0.00243	0.880180	0.004532	3.784410
22		0.877970	0.00254	0.880180	-0.002210	4.049750
23		0.871840	0.00264	0.872720	0.000880	4.315090
24		0.866237	0.00274	0.863020	0.003217	4.580430
25		0.861091	0.00284	0.857800	0.003291	4.845770
26		0.859567	0.00287	0.857800	0.001767	4.923690

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-R(I-1))}{\sqrt{(\sum(R(I))^2+\sum(R(I-1))^2)}}$

SERIAL CORRELATION 0.20846 RESIDUALS ORDERED ON CASE NUMBER

6



PLOT NUMBER										
6-4 T1 0.4% YIELD/TEMPERATURE= 470 C										
TIME BASE										
TOTAL TIME 350.3 MIN										
RECOVERY AT 60.3 MIN										
INCREMENT OF TIME 1.827 MIN										
INPUT VARIABLES										
LINE	STRESS	C0	C1	C0	C1	G2	EX	LENS	YOUNG	ENT
NUMBER	(PSI)									
1	32629.3	0.1175E-02	0.5230E-08	1.0627	1.5630	2.2630	0.39508	0.69826E-03	60.30000	1.06509
0.500E-02										
0.450E-02										
0.400E-02										
0.350E-02										
0.300E-02										
0.250E-02										
0.200E-02										
0.150E-02										
0.100E-02										
0.500E-03										
0.										
20.0	47.0	90.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0
240.0	260.0	280.0	300.0	320.0	340.0	360.0				

ORIGINAL PAGE IS
OF POOR QUALITY

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED. VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		3.2335-1	3.23329	3.23354	0.00025	0.196809
2		3.23354	3.23329	3.23354	0.00025	0.293393
3		3.23354	3.23329	3.23354	0.00025	1.293309
4		3.23354	3.23329	3.23354	0.00025	2.293309
5		3.23354	3.23329	3.23354	0.00025	3.293309
6		3.23354	3.23329	3.23354	0.00025	4.293309
7		3.23354	3.23329	3.23354	0.00025	5.293309
8		3.23354	3.23329	3.23354	0.00025	6.293309
9		3.23354	3.23329	3.23354	0.00025	7.293309
10		3.23354	3.23329	3.23354	0.00025	8.293309
11		3.23354	3.23329	3.23354	0.00025	9.293309
12		3.23354	3.23329	3.23354	0.00025	10.293309
13		3.23354	3.23329	3.23354	0.00025	11.293309
14		3.23354	3.23329	3.23354	0.00025	12.293309
15		3.23354	3.23329	3.23354	0.00025	13.293309
16		3.23354	3.23329	3.23354	0.00025	14.293309
17		3.23354	3.23329	3.23354	0.00025	15.293309
18		3.23354	3.23329	3.23354	0.00025	16.293309
19		3.23354	3.23329	3.23354	0.00025	17.293309
20		3.23354	3.23329	3.23354	0.00025	18.293309
21		3.23354	3.23329	3.23354	0.00025	19.293309
22		3.23354	3.23329	3.23354	0.00025	20.293309
23		3.23354	3.23329	3.23354	0.00025	21.293309
24		3.23354	3.23329	3.23354	0.00025	22.293309
25		3.23354	3.23329	3.23354	0.00025	23.293309
26		3.23354	3.23329	3.23354	0.00025	24.293309
27		3.23354	3.23329	3.23354	0.00025	25.293309
28		3.23354	3.23329	3.23354	0.00025	26.293309
29		3.23354	3.23329	3.23354	0.00025	27.293309
30		3.23354	3.23329	3.23354	0.00025	28.293309
31		3.23354	3.23329	3.23354	0.00025	29.293309
32		3.23354	3.23329	3.23354	0.00025	30.293309
33		3.23354	3.23329	3.23354	0.00025	31.293309
34		3.23354	3.23329	3.23354	0.00025	32.293309
35		3.23354	3.23329	3.23354	0.00025	33.293309
36		3.23354	3.23329	3.23354	0.00025	34.293309
37		3.23354	3.23329	3.23354	0.00025	35.293309
38		3.23354	3.23329	3.23354	0.00025	36.293309
39		3.23354	3.23329	3.23354	0.00025	37.293309
40		3.23354	3.23329	3.23354	0.00025	38.293309
41		3.23354	3.23329	3.23354	0.00025	39.293309
42		3.23354	3.23329	3.23354	0.00025	40.293309

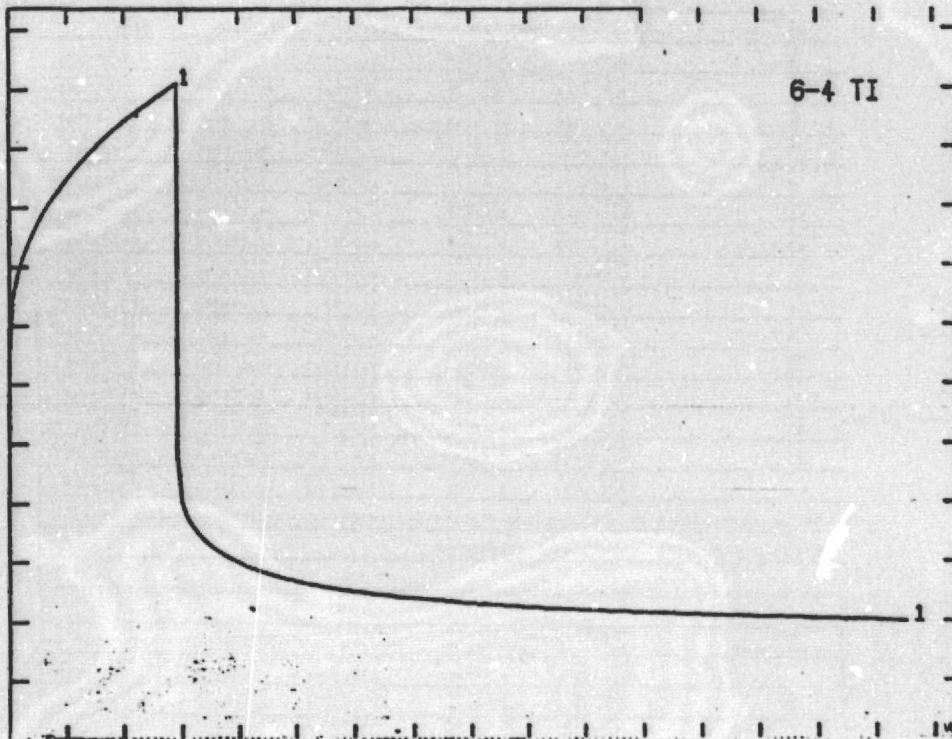
SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R_i - \bar{R})(R_{i-1} - \bar{R})}{\sqrt{(\sum (R_i - \bar{R})^2)(\sum (R_{i-1} - \bar{R})^2)}}$

SERIAL CORRELATION 0.42288 RESIDUALS ORDERED ON CASE NUMBER

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED. VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		2.221692	0.00782	2.221692	0.000000	0.003430
2		2.048930	0.00520	2.048930	0.000000	0.003430
3		1.962778	0.00416	1.962778	0.000000	0.003430
4		1.901158	0.00337	1.901158	0.000000	0.003430
5		1.852109	0.00252	1.852109	0.000000	0.003430
6		1.811123	0.00160	1.811123	0.000000	0.003430
7		1.776382	0.00088	1.776382	0.000000	0.003430
8		1.745430	0.00028	1.745430	0.000000	0.003430
9		1.717277	0.00028	1.717277	0.000000	0.003430
10		1.691908	0.00277	1.691908	0.000000	0.003430
11		1.669446	0.00280	1.669446	0.000000	0.003430
12		1.648448	0.00283	1.648448	0.000000	0.003430
13		1.628288	0.00285	1.628288	0.000000	0.003430
14		1.608632	0.00287	1.608632	0.000000	0.003430
15		1.589260	0.00287	1.589260	0.000000	0.003430
16		1.570090	0.00286	1.570090	0.000000	0.003430
17		1.551547	0.00282	1.551547	0.000000	0.003430
18		1.533690	0.00277	1.533690	0.000000	0.003430
19		1.516521	0.00271	1.516521	0.000000	0.003430
20		1.500000	0.00264	1.500000	0.000000	0.003430
21		1.484123	0.00257	1.484123	0.000000	0.003430
22		1.468890	0.00251	1.468890	0.000000	0.003430
23		1.454202	0.00245	1.454202	0.000000	0.003430
24		1.439959	0.00238	1.439959	0.000000	0.003430
25		1.426161	0.00230	1.426161	0.000000	0.003430
26		1.412808	0.00225	1.412808	0.000000	0.003430
27		1.399900	0.00223	1.399900	0.000000	0.003430
28		1.387438	0.00224	1.387438	0.000000	0.003430
29		1.375414	0.00224	1.375414	0.000000	0.003430
30		1.363826	0.00224	1.363826	0.000000	0.003430
31		1.352672	0.00224	1.352672	0.000000	0.003430
32		1.341951	0.00224	1.341951	0.000000	0.003430
33		1.331662	0.00224	1.331662	0.000000	0.003430
34		1.321806	0.00224	1.321806	0.000000	0.003430
35		1.312383	0.00224	1.312383	0.000000	0.003430
36		1.303394	0.00224	1.303394	0.000000	0.003430
37		1.294839	0.00224	1.294839	0.000000	0.003430
38		1.286719	0.00224	1.286719	0.000000	0.003430
39		1.279044	0.00224	1.279044	0.000000	0.003430
40		1.271814	0.00224	1.271814	0.000000	0.003430
41		1.265029	0.00224	1.265029	0.000000	0.003430
42		1.258690	0.00224	1.258690	0.000000	0.003430

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R_i - \bar{R})(R_{i-1} - \bar{R})}{\sqrt{(\sum (R_i - \bar{R})^2)(\sum (R_{i-1} - \bar{R})^2)}}$

SERIAL CORRELATION 0.87194 RESIDUALS ORDERED ON CASE NUMBER



PLOT NUMBER									
6-4 TI 0.5 YIELD TEMPERATURE= 470 C									
TIME BASE									
TOTAL TIME 310.3 MIN									
RECOVERY AT 18.3 MIN									
INCREMENT OF TIME 1.575 MIN									
INPUT VARIABLES									
LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7
NUMBER	(PSI)								
1	38210.0	1.6440E-02	0.20	3.2103E-01	0.0450	1.4560E-02	0.1100	0.384590	7.1877E-11
0.400E-02									
0.550E-02									
0.500E-02									
0.450E-02									
0.400E-02									
0.350E-02									
0.300E-02									
0.250E-02									
0.200E-02									
0.150E-02									
0.100E-02									
0.500E-01									
0.									
22.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
220.0	240.0	260.0	280.0	300.0	320.0				

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.851988	0.00499	1.854390	0.002402	0.240000
2	2.255223	0.00283	2.034490	-0.220733	1.240000
3	2.191003	0.00210	2.147100	-0.043903	2.760000
4	2.244121	0.00195	2.233400	-0.010721	4.240000
5	2.345023	0.00149	2.338900	-0.006123	8.240000
6	2.433124	0.00187	2.428530	-0.004594	8.240000
7	2.521134	0.00149	2.511210	-0.009924	10.240000
8	2.540135	0.00130	2.530210	-0.009925	12.240000
9	2.640922	0.00174	2.644340	0.003418	14.240000
10	2.714558	0.00167	2.722050	0.007492	16.240000
11	2.761279	0.00159	2.762710	0.001431	18.240000
12	2.814912	0.00151	2.819110	0.004198	20.240000
13	2.855990	0.00140	2.867810	0.011820	22.240000
14	2.914406	0.00139	2.927870	0.013464	24.240000
15	2.951791	0.00135	2.955410	0.003619	26.240000
16	3.026987	0.00135	3.026450	-0.000537	28.240000
17	3.091632	0.00133	3.097980	0.006348	30.240000
18	3.092886	0.00144	3.093030	-0.000144	32.240000
19	3.133003	0.00153	3.130570	-0.002433	34.240000
20	3.173404	0.00165	3.164350	-0.009054	36.240000
21	3.212136	0.00180	3.205640	-0.006496	38.240000
22	3.251204	0.00196	3.246930	-0.004274	40.240000
23	3.237159	0.00216	3.231970	-0.005189	42.240000
24	3.321166	0.00233	3.325760	0.004594	44.240000
25	3.312529	0.00244	3.315200	0.002671	46.240000

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) * R(I-1))}{\sqrt{(\sum(R(I)^2) * \sum(R(I-1)^2))}}$

SERIAL CORRELATION 0.49567
RESIDUALS ORDERED BY CASE NUMBER

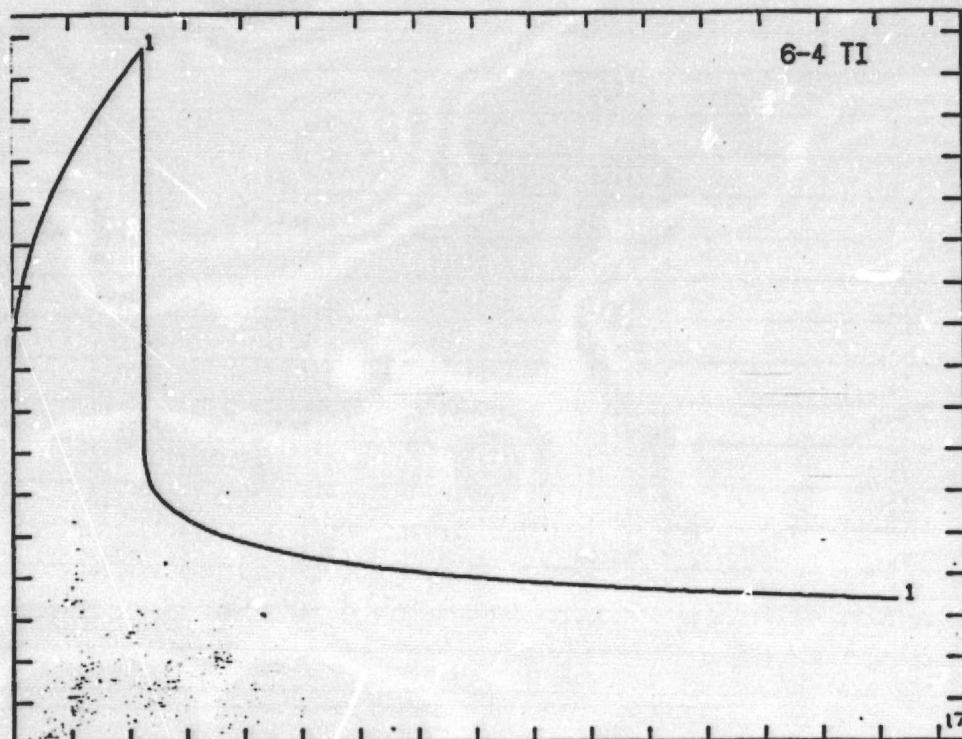
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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.304970	0.00449	1.322800	0.017830	0.010140
2	1.261415	0.00386	1.249970	-0.011445	0.032190
3	1.210707	0.00293	1.193670	-0.017037	0.076300
4	1.155967	0.00241	1.139820	-0.016147	0.186550
5	1.086865	0.00238	1.088570	0.001705	0.296800
6	1.008196	0.00249	1.009740	0.001544	0.561410
7	0.955120	0.00247	0.960940	0.005820	0.526020
8	0.915133	0.00237	0.919830	0.004697	1.090630
9	0.883237	0.00222	0.885870	0.002633	1.355240
10	0.856553	0.00205	0.855843	-0.000710	1.819850
11	0.834489	0.00189	0.833320	-0.001169	1.884450
12	0.813159	0.00178	0.814530	0.001371	2.149060
13	0.798211	0.00165	0.792030	-0.006181	2.412670
14	0.783175	0.00158	0.780780	-0.002395	2.870280
15	0.769706	0.00154	0.761250	-0.008456	2.942890
16	0.757543	0.00154	0.755240	-0.002303	3.207500
17	0.746481	0.00158	0.749980	0.003499	3.472110
18	0.736360	0.00165	0.743230	0.006870	3.736710
19	0.727051	0.00173	0.728210	0.001159	4.001320
20	0.718450	0.00185	0.719200	0.000750	4.265930
21	0.710468	0.00195	0.716950	0.006482	4.530540
22	0.703034	0.00207	0.701940	-0.001094	4.795150
23	0.696088	0.00219	0.696680	0.000592	5.059760
24	0.689576	0.00232	0.685420	-0.004156	5.324370
25	0.683457	0.00244	0.681670	-0.001787	5.588970
26	0.679575	0.00252	0.680170	0.000595	5.763380

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) * R(I-1))}{\sqrt{(\sum(R(I)^2) * \sum(R(I-1)^2))}}$

SERIAL CORRELATION 0.07603
RESIDUALS ORDERED BY CASE NUMBER

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INPUT VARIABLES										
TIME NUMBER	STRESS (PSI)	CU	CT	CO	CI	CE	CA	CEMC	TIME	END
1	20975.0.9464E-35	0.4250E-08	1.0000	1.5905	1.0500	0.50325	0.57662E-63	45.54333	0.40020	
0.340E-02										
0.520E-02										
0.300E-02										
0.280E-02										
0.290E-02										
0.240E-02										
0.220E-02										
0.230E-02										
0.150E-02										
0.160E-02										
0.170E-02										
0.120E-02										
0.100E-02										
0.800E-03										
0.800E-03										
0.400E-03										
0.200E-03										
0.										
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0
240.0	260.0	280.0	300.0	320.0						

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.54752	1.01011	2.518530	-0.02902	0.100300
2	2.766264	1.00572	2.732190	-0.03407	1.100000
3	2.990092	1.00371	2.958120	-0.03197	2.100000
4	3.253112	1.00141	3.229460	-0.02365	3.100000
5	3.443317	1.00040	3.425390	-0.01793	4.100000
6	3.632770	1.00001	3.609030	-0.02374	5.100000
7	3.849123	1.00000	3.825300	-0.02382	6.100000
8	4.076149	1.00000	4.052150	-0.02400	7.100000
9	4.3256132	1.00000	4.301630	-0.02398	8.100000
10	4.590453	1.00000	4.566470	-0.02398	9.100000
11	4.870227	1.00000	4.846250	-0.02397	10.100000
12	5.166154	1.00000	5.142170	-0.02398	11.100000
13	5.478411	1.00000	5.454430	-0.02398	12.100000
14	5.808082	1.00000	5.784100	-0.02398	13.100000
15	6.154640	1.00000	6.130660	-0.02398	14.100000
16	6.518199	1.00000	6.494210	-0.02398	15.100000
17	6.898337	1.00000	6.874350	-0.02398	16.100000
18	7.295040	1.00000	7.271060	-0.02398	17.100000
19	7.708611	1.00000	7.684630	-0.02398	18.100000
20	8.139449	1.00000	8.115470	-0.02398	19.100000
21	8.587940	1.00000	8.563960	-0.02398	20.100000
22	9.054690	1.00000	9.030710	-0.02398	21.100000
23	9.539129	1.00000	9.515150	-0.02398	22.100000
24	10.041822	1.00000	10.017850	-0.02398	23.100000
25	10.563560	1.00000	10.539580	-0.02398	24.100000

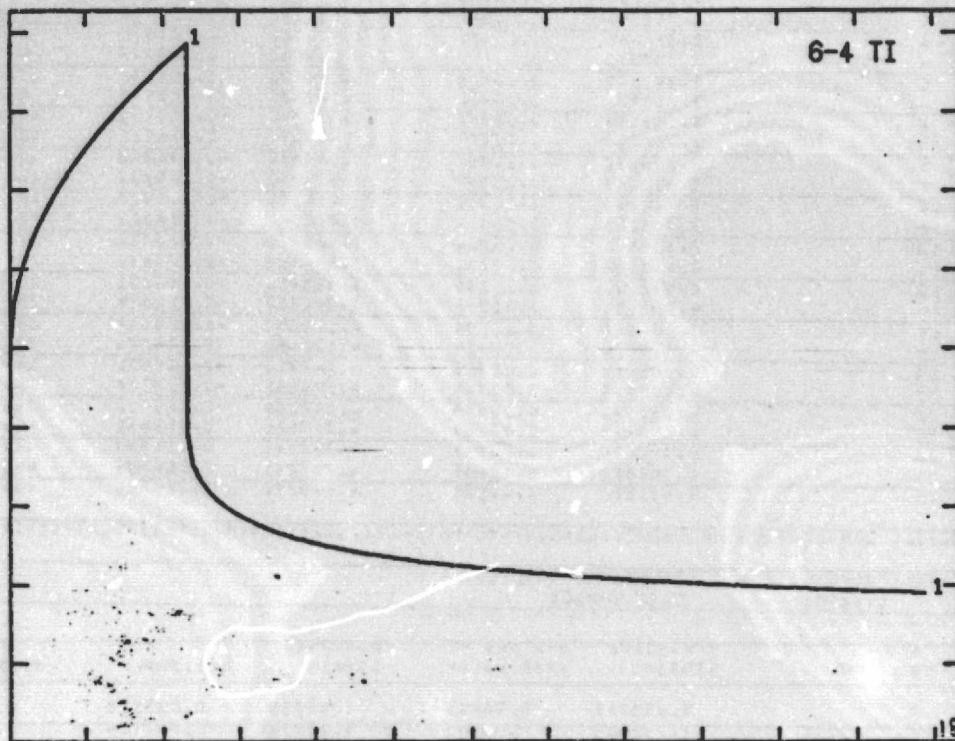
SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R(I) \cdot R(I-1))}{\sqrt{(\sum (R(I)^2) \cdot \sum (R(I-1)^2))}}$

SERIAL CORRELATION 0.52251 RESIDUALS ORDERED BY CASE NUMBER 18

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.853323	0.00925	1.888900	0.035577	0.006480
2	1.737083	0.00885	1.739380	-0.002297	0.020800
3	1.658209	0.00523	1.621300	-0.036909	0.071270
4	1.564703	0.00439	1.542800	-0.021903	0.157870
5	1.455521	0.00463	1.452090	-0.003431	0.265660
6	1.370933	0.00587	1.369430	-0.001503	0.410830
7	1.302702	0.00451	1.323800	0.021098	0.589630
8	1.251378	0.00423	1.239270	-0.012108	0.782620
9	1.210647	0.00392	1.215980	0.005333	0.935210
10	1.177173	0.00381	1.178630	0.001457	1.107990
11	1.148963	0.00333	1.147510	-0.001453	1.280780
12	1.126731	0.00309	1.127040	0.000309	1.453580
13	1.103601	0.00291	1.105790	0.002189	1.626350
14	1.084951	0.00279	1.093990	0.009039	1.799160
15	1.068324	0.00273	1.078250	0.009926	1.971920
16	1.053374	0.00272	1.066780	0.013406	2.144710
17	1.039833	0.00276	1.049600	-0.009767	2.317490
18	1.027490	0.00284	1.019220	-0.008270	2.490280
19	1.016177	0.00295	1.007410	-0.008767	2.663070
20	1.005757	0.00309	1.007410	0.001653	2.835850
21	0.996118	0.00323	1.007410	0.011292	3.008640
22	0.987165	0.00339	0.985800	-0.001365	3.181430
23	0.978823	0.00355	0.975930	-0.002893	3.354210
24	0.971023	0.00372	0.972000	0.000977	3.527000
25	0.963708	0.00389	0.960190	-0.003518	3.699780
26	0.956831	0.00406	0.950730	-0.006101	3.872570
27	0.950348	0.00422	0.949170	-0.001178	4.045360
28	0.944244	0.00430	0.949170	0.004926	4.218150

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R(I) \cdot R(I-1))}{\sqrt{(\sum (R(I)^2) \cdot \sum (R(I-1)^2))}}$

SERIAL CORRELATION 0.13920 RESIDUALS ORDERED BY CASE NUMBER 18



PLUG NUMBER										
6-4 TI 0.40=YIELD/TEMPERATURE= 465 C										
TIME BASE										
TOTAL TIME 237.5 MIN										
RECOVERY AT 40.5 MIN										
INCREMENT OF TIME 1.015 MIN										
INPUT VARIABLES										
LINE	STRESS	CU	CT	DU	GT	GE	SA	LEND	TIME	END
NUMBER (PSI)										
1	2796J.0.1552E-02	0.4253E-08	1.0356	1.4287	1.5559	0.4900	0.420E-03	40.30JJ	0.42390	
0.430E-02										
0.130E-02										
0.330E-02										
0.500E-02										
0.250E-02										
0.200E-02										
0.150E-02										
0.100E-02										
0.700E-03										
0.										
20.0	40.0	80.0	120.0	160.0	200.0	240.0	280.0	320.0	360.0	400.0

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CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		2.630505	0.00247	2.643790	-0.037796	0.160000
2		2.743677	0.00364	2.922600	-0.020679	1.160000
3		3.081926	0.00367	3.078033	-0.003096	2.160000
4		3.274931	0.00390	3.230540	-0.005609	4.160000
5		3.419963	0.00375	3.440380	0.020417	6.160000
6		3.540244	0.00355	3.554350	0.014306	8.160000
7		3.644032	0.00334	3.653500	0.008468	10.160000
8		3.738561	0.00313	3.744340	0.005779	12.160000
9		3.823572	0.00293	3.824760	0.001188	14.160000
10		3.902243	0.00270	3.900370	-0.001873	16.160000
11		3.975003	0.00263	3.969370	-0.005633	18.160000
12		4.044541	0.00253	4.041680	-0.002861	20.160000
13		4.109727	0.00247	4.117800	0.008073	22.160000
14		4.171677	0.00240	4.167270	-0.004407	24.160000
15		4.230403	0.00250	4.220550	-0.009853	26.160000
16		4.287435	0.00257	4.289060	0.001625	28.160000
17		4.341845	0.00269	4.338530	-0.003315	30.160000
18		4.394260	0.00283	4.371810	-0.022450	32.160000
19		4.444869	0.00301	4.448900	0.004031	34.160000
20		4.493236	0.00320	4.490760	-0.002476	36.160000
21		4.541301	0.00341	4.544040	0.002739	38.160000
22		4.587386	0.00364	4.582100	-0.005286	40.160000
23		4.632195	0.00387	4.627700	-0.004495	42.160000
24		4.675823	0.00411	4.671040	-0.004783	44.160000
25		4.704855	0.00428	4.703880	-0.000975	45.520000

SERIAL CORRELATION OF RESIDUALS = $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.62975 RESIDUALS ORDERED ON CASE NUMBER

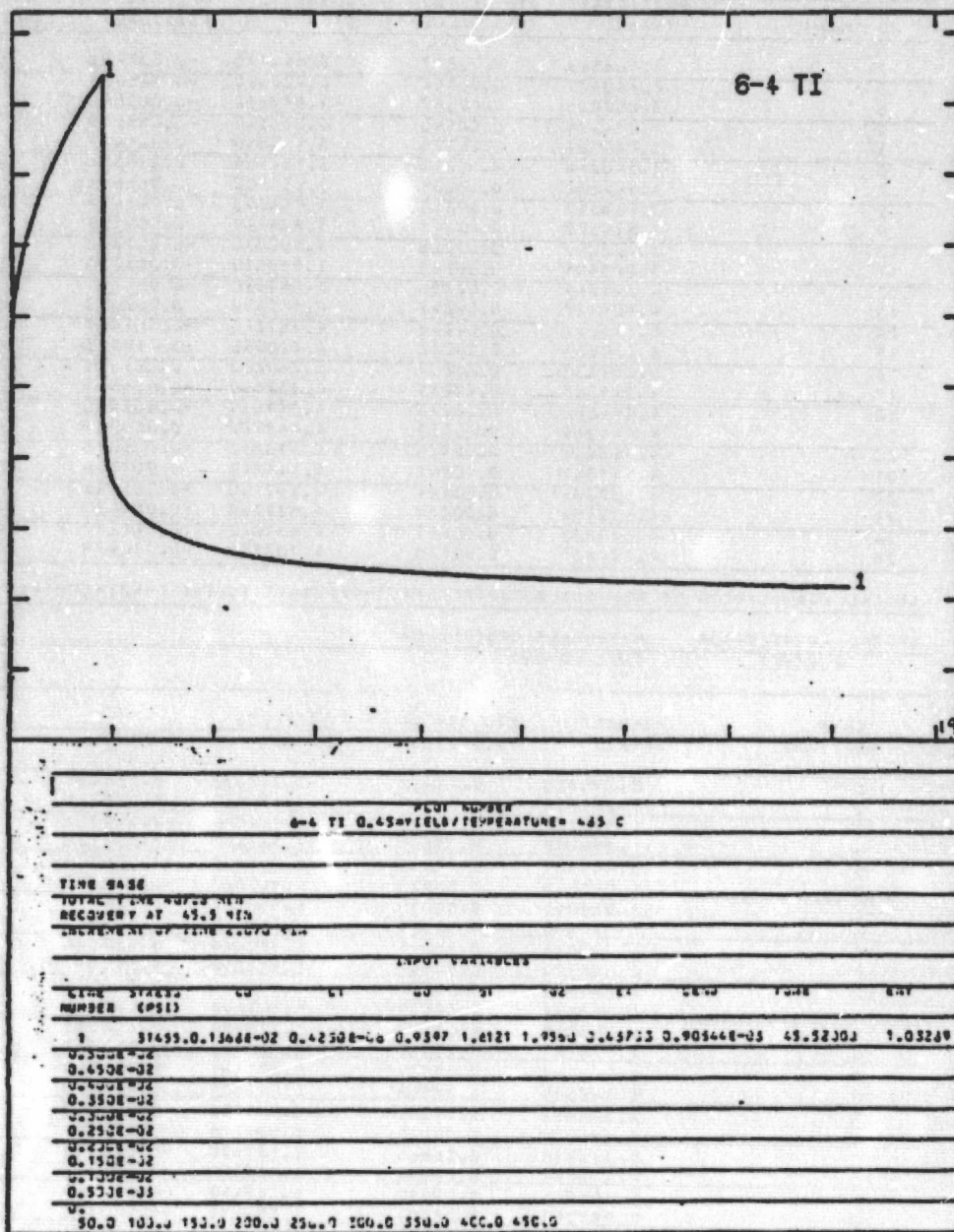
19

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1		2.178029	0.01402	2.207320	0.029291	0.002200
2		2.122686	0.01209	2.135010	0.012324	0.006590
3		1.997350	0.00945	1.986594	-0.010756	0.008560
4		1.876352	0.00833	1.861600	-0.014752	0.012500
5		1.770867	0.00865	1.746830	-0.024037	0.013940
6		1.680026	0.00925	1.647803	-0.032223	0.016270
7		1.589241	0.00959	1.552740	-0.036501	0.018080
8		1.427306	0.00975	1.440850	0.013544	0.019740
9		1.343016	0.00748	1.370060	0.027044	0.023600
10		1.288723	0.00647	1.324390	0.035667	0.026170
11		1.249973	0.00579	1.290140	0.040167	0.028550
12		1.229536	0.00539	1.244470	0.014934	0.029420
13		1.197208	0.00522	1.210220	0.013012	0.029940
14		1.178143	0.00521	1.188910	0.010767	0.030360
15		1.162191	0.00531	1.172160	0.009969	0.030720
16		1.148595	0.00543	1.160750	0.012155	0.031230
17		1.136832	0.00569	1.141720	0.004888	0.031740
18		1.126528	0.00591	1.122690	-0.003838	0.032120
19		1.117408	0.00614	1.107470	-0.009938	0.032470
20		1.109262	0.00639	1.107470	-0.001792	0.032860
21		1.101931	0.00660	1.088440	-0.013491	0.033230
22		1.095291	0.00683	1.073220	-0.022071	0.033590
23		1.089237	0.00704	1.069410	-0.019827	0.033960
24		1.083692	0.00724	1.051020	-0.032672	0.034330
25		1.082117	0.00730	1.061800	-0.020317	0.034740

SERIAL CORRELATION OF RESIDUALS = $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.78388 RESIDUALS ORDERED ON CASE NUMBER

19



F24

ORIGINAL PAGE IS
OF POOR QUALITY

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	3.725479	1.01314	3.722931	-0.002548	3.145300
2	4.064434	1.00755	4.063810	-0.000624	3.149000
3	4.323958	1.00955	4.322230	-0.001728	2.555733
4	4.521633	1.012542	4.550213	0.028580	4.160333
5	4.725374	1.00827	4.738490	0.013116	6.180733
6	4.937431	1.01516	4.911330	-0.026101	8.150733
7	5.144126	1.01175	5.160150	0.016024	10.160733
8	5.143146	1.01491	5.185670	0.042524	12.160733
9	5.356559	1.00675	5.303350	-0.053209	14.160733
10	5.421562	1.01443	5.416320	-0.005242	16.160733
11	5.523913	1.01420	5.522010	-0.001903	18.160733
12	5.635139	1.01403	5.617130	-0.018009	20.160733
13	5.725135	1.01363	5.711330	-0.013805	22.160733
14	5.817014	1.01375	5.797590	-0.019424	24.160733
15	5.913138	1.01358	5.883890	-0.029248	26.160733
16	5.999103	1.01370	5.962340	-0.036763	28.160733
17	6.077102	1.01373	6.040840	-0.036262	30.160733
18	6.144149	1.01396	6.156630	0.012481	32.160733
19	6.213088	1.01421	6.221230	0.008142	34.160733
20	6.296954	1.01452	6.307530	0.010576	36.160733
21	6.367992	1.01483	6.372290	0.004300	38.160733
22	6.437119	1.01531	6.468740	0.031621	40.160733
23	6.514435	1.01575	6.513350	-0.001085	42.160733
24	6.577159	1.01624	6.562110	-0.015049	44.160733
25	6.640461	1.01679	6.600500	-0.039961	46.160733

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)*R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)*\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.75602 CASE NUMBER

20

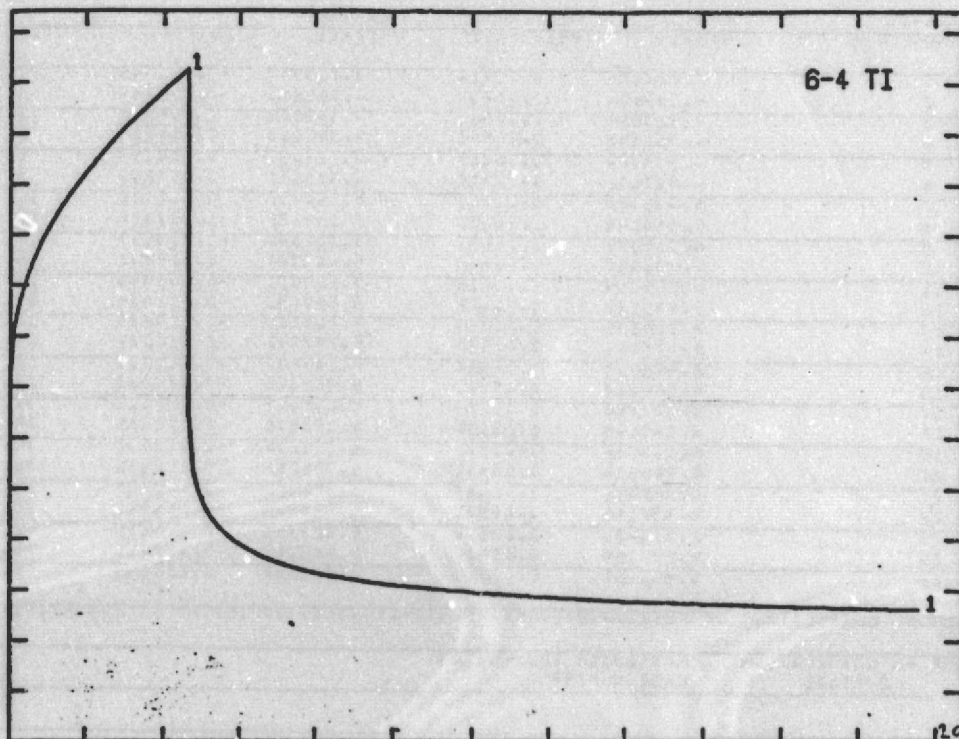
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	2.884165	0.01291	2.887030	0.002865	0.008630
2	2.838518	0.00841	2.843830	0.005312	0.030200
3	2.394751	0.00711	2.384940	-0.009811	0.073340
4	2.105114	0.00754	2.083680	-0.021434	0.181190
5	1.884995	0.00707	1.882850	-0.002145	0.353750
6	1.737855	0.00599	1.737320	-0.000535	0.569480
7	1.646630	0.00507	1.663180	0.016550	0.785160
8	1.582909	0.00440	1.508280	-0.074629	1.000860
9	1.535156	0.00397	1.550210	0.015054	1.216370
10	1.497880	0.00372	1.482740	-0.015140	1.432270
11	1.467214	0.00362	1.435670	-0.031544	1.647970
12	1.447861	0.00350	1.412130	-0.035731	1.863680
13	1.420329	0.00369	1.412130	-0.008199	2.079380
14	1.401749	0.00381	1.410580	0.008831	2.295080
15	1.385506	0.00395	1.396440	0.010934	2.510790
16	1.371151	0.00411	1.388800	0.017649	2.726490
17	1.358347	0.00427	1.365060	0.006713	2.942190
18	1.346834	0.00443	1.352310	0.005476	3.157890
19	1.336410	0.00459	1.333680	-0.002730	3.373600
20	1.326915	0.00474	1.325840	-0.001075	3.589300
21	1.318220	0.00489	1.310150	-0.008070	3.805000
22	1.310218	0.00504	1.305440	-0.004778	4.020710
23	1.307192	0.00509	1.305440	-0.001752	4.106990

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)*R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)*\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.62734 CASE NUMBER

20

F26



PCUT ZUPPER										
6-4 TI 0.50=YIELD/TEMPERATURE= 465 C										
TIME BASE										
TOTAL TIME 233.4 MIN										
RECOVERY AT 46.4 MIN										
INCREMENT OF TIME 1.000 MIN										
INPUT VARIABLES										
CASE NUMBER	STRESS (PSI)	CU	CT	CC	CT	CC	CT	CC	TIME	END
1	54950.0.2217E-02	U.4250E-08	1.1834	1.4146	3.9955	0.46692	C.12257E-02	46.36J0J	2.75613	
0.700E-02										
0.650E-02										
0.600E-02										
0.550E-02										
0.500E-02										
0.450E-02										
0.400E-02										
0.350E-02										
0.300E-02										
0.250E-02										
0.200E-02										
0.150E-02										
0.100E-02										
0.050E-02										
0.00E-02										
23.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0 240.0

F26

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.244825	G.C2881	1.691360	-0.022956	0.250000
2	1.339007	G.C0534	1.651130	0.011493	1.250000
3	1.215465	G.C0434	1.249350	0.033885	2.250000
4	2.376333	G.C0384	2.090610	0.020271	4.250000
5	2.136163	G.C0178	2.147760	0.001597	6.250000
6	2.279813	G.C0375	2.235930	0.003883	8.250000
7	2.322685	G.C0367	2.370040	0.007355	10.250000
8	2.437421	G.C0355	2.433160	-0.004261	12.250000
9	2.554652	G.C0340	2.495770	-0.058882	14.250000
10	2.570805	G.C0322	2.512910	-0.007896	16.250000
11	2.511307	G.C0305	2.422510	-0.018797	18.250000
12	2.668578	G.C0290	2.682110	0.003532	20.250000
13	2.743024	G.C0274	2.736210	-0.006814	22.250000
14	2.795202	G.C0271	2.794300	-0.000902	24.250000
15	2.465211	G.C0271	2.460900	-0.004311	26.250000
16	2.393350	G.C0279	2.495980	0.002630	28.250000
17	2.239817	G.C0295	2.234550	-0.005267	30.250000
18	2.984773	G.C0318	2.970620	-0.004153	32.250000
19	3.028157	G.C0347	3.022200	-0.005957	34.250000
20	3.070644	G.C0381	3.071280	0.000636	36.250000
21	3.111408	G.C0419	3.120370	0.008962	38.250000
22	3.151937	G.C0460	3.162440	0.010503	40.250000
23	3.171673	G.C0482	3.183670	0.011997	42.250000

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-R(I-1))}{\sqrt{(\sum(R(I))^2 - 2 \cdot \sum(R(I) \cdot R(I-1)) + \sum(R(I-1))^2)}}$

SERIAL CORRELATION RESIDUALS ORDERED ON
C.43933 CASE NUMBER

1

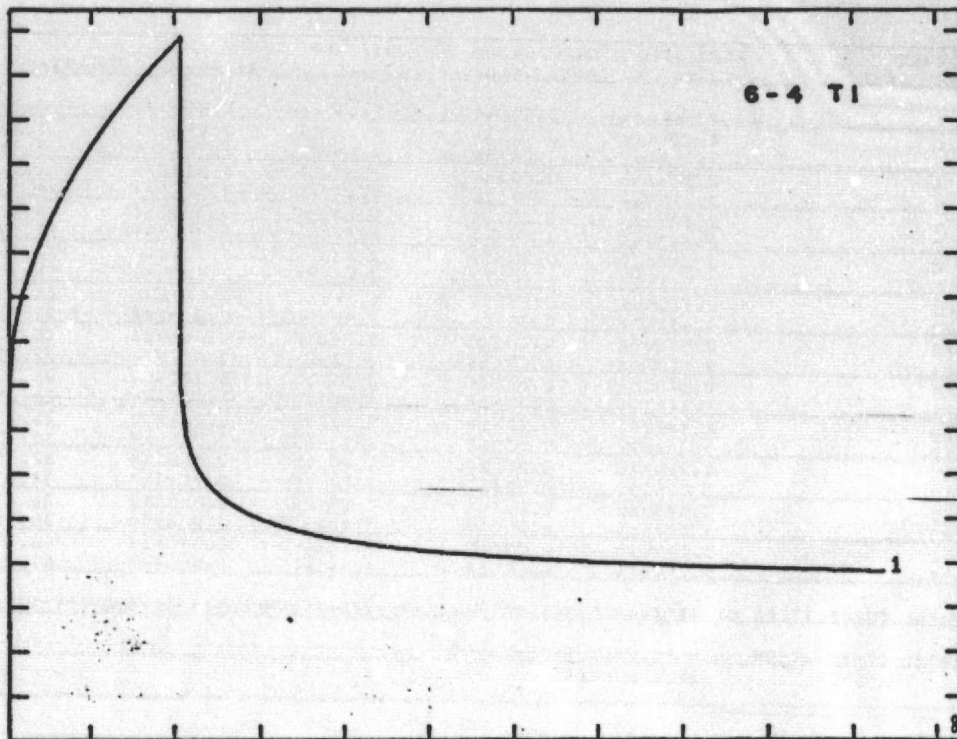
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.498707	0.01135	1.500580	0.001873	0.004380
2	1.363183	0.00677	1.349820	-0.013363	0.028580
3	1.295251	0.00596	1.293720	-0.001531	0.052990
4	1.210587	0.00801	1.227110	0.016523	0.107500
5	1.054881	0.00607	1.069360	0.014479	0.296060
6	0.998927	0.00550	1.006230	0.007303	0.441910
7	0.946870	0.00473	0.946630	-0.000240	0.636360
8	0.912578	0.00409	0.911570	-0.001008	0.830820
9	0.887146	0.00363	0.867390	-0.019756	1.025280
10	0.867295	0.00351	0.837940	-0.029355	1.219740
11	0.851235	0.00313	0.816900	-0.034335	1.414200
12	0.837891	0.00305	0.841450	0.003559	1.608650
13	0.826571	0.00304	0.837940	0.011369	1.803110
14	0.816810	0.00309	0.830930	0.014120	1.997570
15	0.808280	0.00317	0.820410	0.012130	2.192030
16	0.800741	0.00328	0.802880	0.002139	2.386490
17	0.794014	0.00340	0.792360	-0.001654	2.580940
18	0.787964	0.00353	0.785350	-0.002614	2.775400
19	0.782484	0.00366	0.774830	-0.007654	2.969860
20	0.777489	0.00379	0.781840	0.004351	3.164320
21	0.772913	0.00392	0.781840	0.008927	3.358770
22	0.768698	0.00405	0.781840	0.013142	3.553230
23	0.764801	0.00417	0.774830	0.010029	3.747690
24	0.762064	0.00426	0.760810	-0.001254	3.942150
25	0.759469	0.00434	0.750290	-0.009179	4.136610

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I)-R(I-1))}{\sqrt{(\sum(R(I))^2 - 2 \cdot \sum(R(I) \cdot R(I-1)) + \sum(R(I-1))^2)}}$

SERIAL CORRELATION RESIDUALS ORDERED ON
U.60100 CASE NUMBER

8

27



PLOT NUMBER										
6-4 T1 0.5 YIELD/TEMPERATURE= 500 C										
TIME BASE										
TOTAL TIME 237.5 MIN										
RECOVERY AT 41.5 MIN										
INCREMENT OF TIME 1.003 MIN										
INPUT VARIABLES										
LINE NUMBER	STRESS (PSI)	C0	C1	C2	C3	C4	C5	C6	C7	TIME
1	20107.3	9970E-03	0.1255E-07	1.0000	1.4332	1.0000	0.30072	0.61321E-03	41.25000	2.70613
0.320E-02										
0.300E-02										
0.280E-02										
0.260E-02										
0.240E-02										
0.220E-02										
0.200E-02										
0.180E-02										
0.160E-02										
0.140E-02										
0.120E-02										
0.100E-02										
0.800E-03										
0.600E-03										
0.400E-03										
0.200E-03										
0.										
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.325131	1.003-5	2.813150	-0.012441	1.150333
2	2.935775	1.00307	2.920220	-0.004555	2.150333
3	3.032233	1.00255	3.090890	0.000667	4.150333
4	3.214491	1.00320	3.205960	0.000969	6.150333
5	3.299935	1.00190	3.319121	0.009185	8.150333
6	3.342333	1.00170	3.392000	0.001107	10.150333
7	3.455927	1.00160	3.447423	0.0011923	12.150333
8	3.522854	0.00152	3.531320	0.008465	14.150333
9	3.584598	1.00147	3.582930	-1.001698	16.150333
10	3.622121	1.00147	3.622410	0.000289	18.150333
11	3.696132	1.00149	3.692330	-0.003802	20.150333
12	3.747167	1.00155	3.745580	-0.001587	22.150333
13	3.795637	1.00152	3.801120	0.005483	24.150333
14	3.841869	0.00171	3.844770	0.002901	26.150333
15	3.886126	0.00160	3.884420	-0.001706	28.150333
16	3.929626	1.00190	3.924133	-0.005493	30.150333
17	3.969546	0.00203	3.967770	-0.001776	32.150333
18	4.019440	1.00211	4.017450	-0.001990	34.150333
19	4.067237	1.00222	4.063150	-0.004087	36.150333
20	4.084246	1.00230	4.079980	-0.004266	38.150333
21	4.12876	1.00239	4.102680	-0.006080	39.150333

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.62612 CASE NUMBER

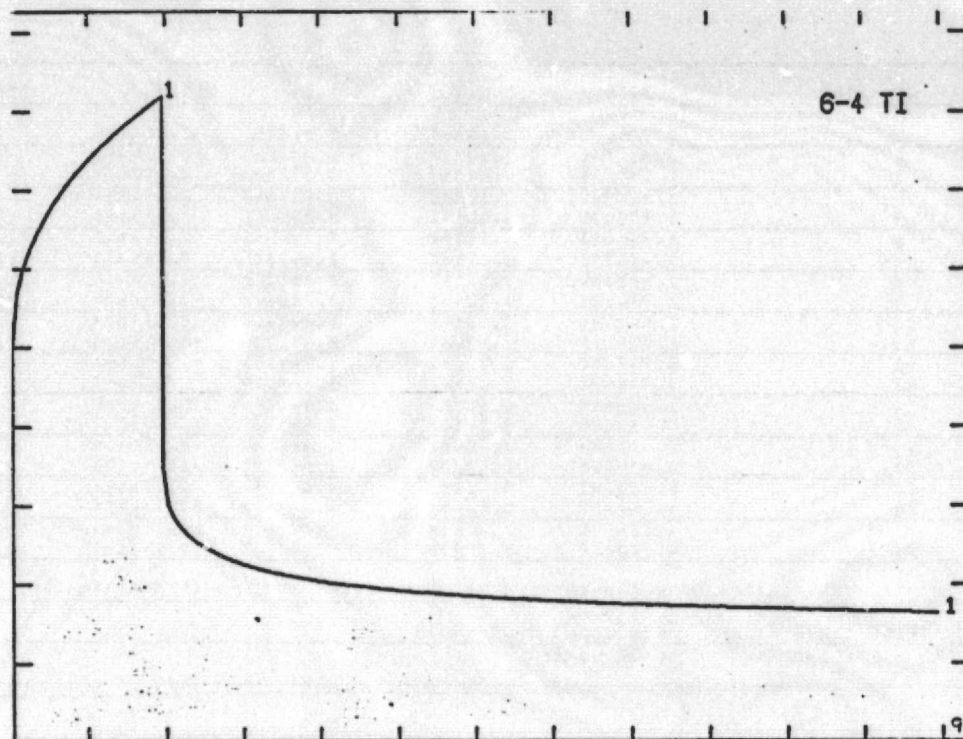
9

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.445956	0.00420	1.452200	0.006244	0.350920
2	1.273811	0.00218	1.265720	-0.008091	0.210080
3	1.174651	0.00195	1.166520	-0.008131	0.383720
4	1.122376	0.00190	1.122880	0.000504	0.541680
5	1.070309	0.00179	1.075270	0.004961	0.746240
6	1.031741	0.00164	1.031620	-0.000121	0.950230
7	1.001582	0.00149	1.003350	0.002268	1.154420
8	0.977126	0.00135	0.980040	0.002914	1.358600
9	0.954758	0.00124	0.956230	0.001472	1.562790
10	0.939451	0.00116	0.944330	0.004879	1.766970
11	0.924505	0.00111	0.924490	-0.000015	1.971150
12	0.911429	0.00110	0.912590	0.001161	2.175340
13	0.899244	0.00111	0.904650	0.005406	2.379530
14	0.889541	0.00116	0.896720	0.007179	2.583720
15	0.880254	0.00121	0.880850	0.000596	2.787900
16	0.871842	0.00128	0.872910	0.001068	2.992090
17	0.864176	0.00136	0.861010	-0.003166	3.196270
18	0.857153	0.00144	0.857040	-0.000113	3.400460
19	0.850490	0.00152	0.846100	-0.004390	3.604650
20	0.844716	0.00160	0.841170	-0.003546	3.808830
21	0.839172	0.00165	0.833230	-0.005942	4.013020
22	0.834547	0.00172	0.833230	-0.001317	4.115110

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.30212 CASE NUMBER

9



PLOT NUMBER									
6-4 TI 0.40=FIELD/TEMPERATURE= 500 C									
TIME BASE									
TOTAL TIME 250.7 MIN									
RECOVERY AT 39.2 MIN									
INCREMENT OF TIME 1.226 MIN									
INPUT VARIABLES									
LINE NUMBER	STRESS (PSI)	C0	C1	C0	C1	*G2	EX	CEND	YONE
1	26833.0	0.1102E-02	0.1255E-07	1.1363	1.4836	0.6606	0.43000	0.63207E-33	39.12000
0.450E-02									0.94453
0.400E-02									
0.350E-02									
0.300E-02									
0.250E-02									
0.200E-02									
0.150E-02									
0.100E-02									
0.050E-02									
0.									
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
220.0	240.0								

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.938906	0.03274	2.822640	-0.116266	0.300000
2	3.196919	0.02022	3.246210	0.049291	1.300000
3	3.366514	0.01613	3.431310	0.064796	2.300000
4	3.503948	0.01452	3.559450	0.055502	3.300000
5	3.623031	0.01396	3.666230	0.043199	4.300000
6	3.827570	0.01388	3.869120	0.041550	5.300000
7	4.003541	0.01398	4.039970	0.036429	6.300000
8	4.160688	0.01390	4.114720	-0.045968	7.300000
9	4.304198	0.01360	4.262440	-0.041758	8.300000
10	4.437228	0.01314	4.395920	-0.041308	9.300000
11	4.561870	0.01257	4.527610	-0.034259	10.300000
12	4.679595	0.01196	4.655790	-0.023805	11.300000
13	4.791487	0.01138	4.769660	-0.021827	12.300000
14	4.898572	0.01091	4.876440	-0.022132	13.300000
15	5.000894	0.01063	4.963220	-0.037674	14.300000
16	5.099571	0.01060	5.085020	-0.014551	15.300000
17	5.194824	0.01087	5.186110	-0.008714	16.300000
18	5.287003	0.01146	5.285780	-0.001223	17.300000
19	5.376400	0.01234	5.374760	-0.001640	18.300000
20	5.463263	0.01348	5.470870	0.007607	19.300000
21	5.547808	0.01483	5.563410	0.015602	20.300000
22	5.630218	0.01636	5.652400	0.022182	21.300000
23	5.710655	0.01803	5.734270	0.023615	22.300000
24	5.756461	0.01906	5.767660	0.011199	23.300000

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I)^2) \cdot \sum(R(I-1)^2))}}$

SERIAL CORRELATION 0.45956 RESIDUALS ORDERED ON CASE NUMBER

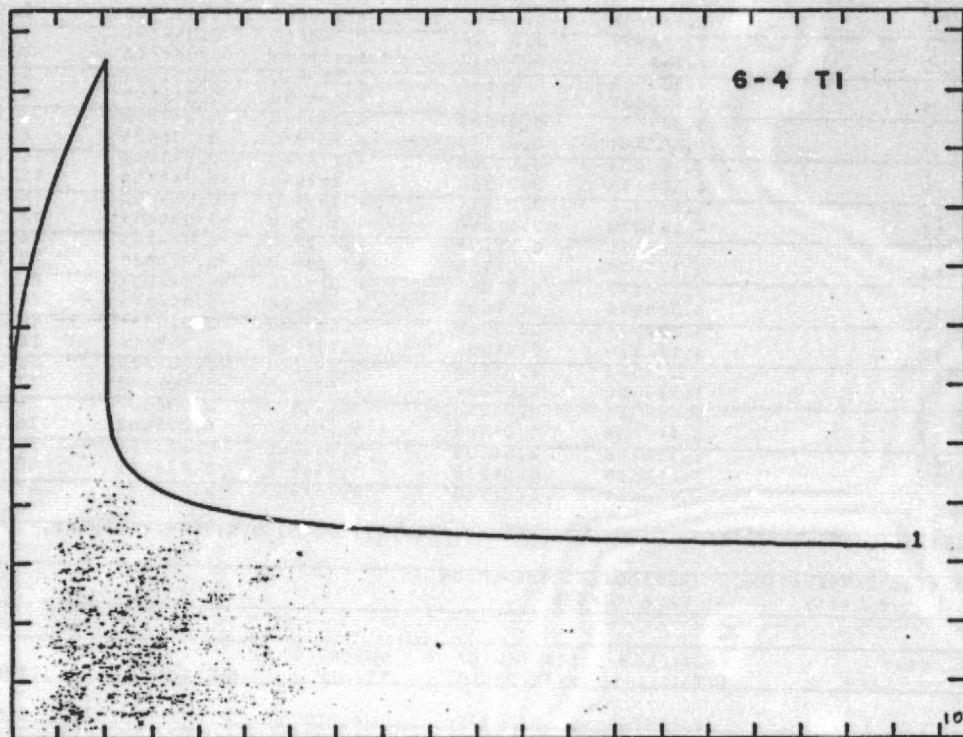
10

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.753954	0.00927	2.779930	0.025976	0.006270
2	2.526265	0.00654	2.599820	-0.073555	0.030390
3	2.437958	0.00502	2.472370	-0.034412	0.078630
4	2.353559	0.00473	2.384830	-0.031271	0.150990
5	2.266259	0.00496	2.260250	0.006009	0.295710
6	2.135845	0.00498	2.149910	-0.014065	0.488660
7	2.141926	0.00477	2.075160	0.066766	0.681420
8	1.964783	0.00418	1.932780	0.032003	1.067530
9	1.901408	0.00366	1.911420	-0.010012	1.453650
10	1.355643	0.00323	1.858030	-0.502387	1.839360
11	1.820503	0.00294	1.821010	-0.000507	2.225280
12	1.792384	0.00276	1.793960	-0.001576	2.611190
13	1.769196	0.00267	1.769040	0.000156	2.997110
14	1.749636	0.00265	1.747690	0.001946	3.383020
15	1.732837	0.00268	1.737010	-0.004173	3.768930
16	1.718199	0.00274	1.719210	-0.001011	4.154850
17	1.705291	0.00282	1.704970	0.000321	4.540760
18	1.693794	0.00292	1.694300	-0.000506	4.926680
19	1.683466	0.00302	1.683620	-0.000154	5.312590
20	1.674120	0.00313	1.665820	0.008300	5.698510
21	1.665608	0.00326	1.662260	0.003348	6.084420
22	1.657812	0.00335	1.658700	-0.000888	6.470330
23	1.650635	0.00366	1.648020	0.002615	6.856250
24	1.644000	0.00356	1.640900	0.003100	7.242160
25	1.637841	0.00366	1.637350	0.000491	7.629080
26	1.632102	0.00376	1.635920	-0.003818	8.013990
27	1.628047	0.00383	1.633790	-0.005743	8.403620

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I)^2) \cdot \sum(R(I-1)^2))}}$

SERIAL CORRELATION -0.13315 RESIDUALS ORDERED ON CASE NUMBER

10



PLOT NUMBER										
6-4 T1 0-4 YIELD/TEMPERATURE 500 C										
TIME BASE										
TOTAL TIME 335.1 MIN										
RECOVERY AT 41.5 MIN										
INCREMENT OF TIME 1.975 MIN										
INPUT VARIABLES										
LINE	STRESS	CO	CT	CG	CT	CG	EX	LEAD	YONE	ENT
NUMBER	(PSI)									
1	30157.3	0.1490E-02	0.1255E-07	1.153	2.0361	0.6271	0.93618	0.13726E-02	41.46700	1.34778
0.600E-02										
0.550E-02										
0.500E-02										
0.450E-02										
0.400E-02										
0.350E-02										
0.300E-02										
0.250E-02										
0.200E-02										
0.150E-02										
0.100E-02										
0.500E-03										
0										
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0
240.0	260.0	280.0	300.0	320.0	340.0					

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	3.199727	0.02322	3.146250	-0.053477	0.200000
2	3.536601	0.01368	3.541290	0.004689	1.200000
3	3.746113	0.01101	3.747030	0.000917	2.200000
4	3.914122	0.01005	3.950450	0.036328	3.200000
5	4.054003	0.00974	4.091530	0.037527	4.200000
6	4.376994	0.00973	4.331360	-0.045634	5.200000
7	4.519792	0.00974	4.543710	0.023918	6.200000
8	4.709553	0.00962	4.712320	0.002767	10.200000
9	4.842637	0.00935	4.881420	0.038783	12.200000
10	5.043073	0.00897	5.042460	-0.000613	14.200000
11	5.193273	0.00854	5.190400	-0.002873	16.200000
12	5.335087	0.00811	5.311940	-0.023147	18.200000
13	5.469834	0.00776	5.431460	-0.038374	20.200000
14	5.598519	0.00749	5.558340	-0.040179	22.200000
15	5.721923	0.00717	5.685820	-0.036103	24.200000
16	5.840669	0.00733	5.805740	-0.034929	26.200000
17	5.955312	0.00789	5.932720	-0.022592	28.200000
18	6.066222	0.00845	6.052650	-0.013572	30.200000
19	6.173722	0.00923	6.179620	0.005898	32.200000
20	6.278265	0.01017	6.292490	0.014225	34.200000
21	6.379959	0.01124	6.405360	0.025401	36.200000
22	6.479078	0.01241	6.504130	0.025052	38.200000
23	6.580595	0.01373	6.631100	0.050505	40.200000

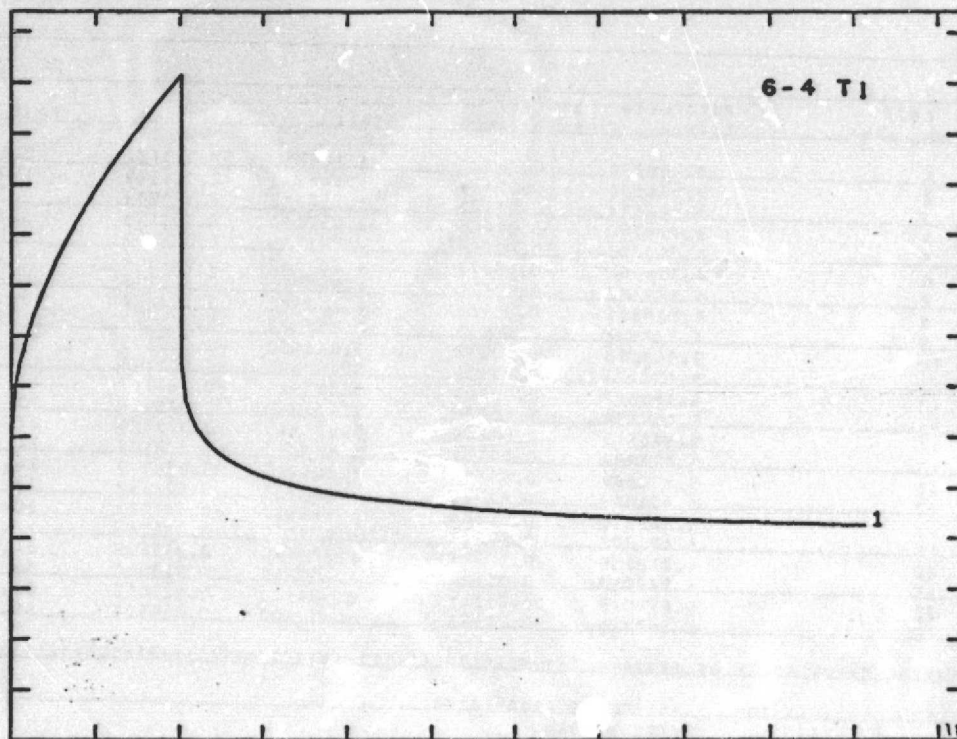
SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I))^2 - \sum(R(I-1))^2)}}$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.78253 CASE NUMBER

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	3.614358	0.01396	3.647110	0.032752	0.002480
2	3.344273	0.00819	3.329660	-0.014613	0.027300
3	3.214840	0.00711	3.188570	-0.026270	0.052110
4	3.051993	0.00705	3.053380	0.001387	0.101740
5	2.862486	0.00736	2.842910	-0.019576	0.200990
6	2.661536	0.00684	2.652440	-0.009096	0.399500
7	2.546677	0.00597	2.567790	0.021113	0.598010
8	2.469015	0.00520	2.490190	0.021175	0.796530
9	2.411747	0.00461	2.437990	0.026243	0.995040
10	2.367161	0.00419	2.384380	0.017219	1.193530
11	2.331124	0.00392	2.342050	0.010926	1.392060
12	2.301183	0.00379	2.306780	0.005597	1.590570
13	2.275776	0.00376	2.285610	0.009834	1.789080
14	2.253852	0.00381	2.264450	0.010598	1.987590
15	2.234674	0.00391	2.243290	0.008616	2.186100
16	2.217706	0.00414	2.219300	0.001594	2.384620
17	2.202553	0.00419	2.208020	0.005467	2.583130
18	2.188908	0.00435	2.186850	-0.002058	2.781640
19	2.176534	0.00452	2.172740	-0.003794	2.980150
20	2.165243	0.00469	2.161460	-0.003783	3.178660
21	2.154886	0.00486	2.144530	-0.010356	3.377170
22	2.145338	0.00503	2.137470	-0.007868	3.575680
23	2.136499	0.00519	2.116310	-0.020189	3.774190
24	2.128185	0.00534	2.109260	-0.018925	3.972700
25	2.125253	0.00540	2.109260	-0.015993	4.049630

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I))^2 - \sum(R(I-1))^2)}}$

SERIAL CORRELATION RESIDUALS ORDERED ON
0.65093 CASE NUMBER

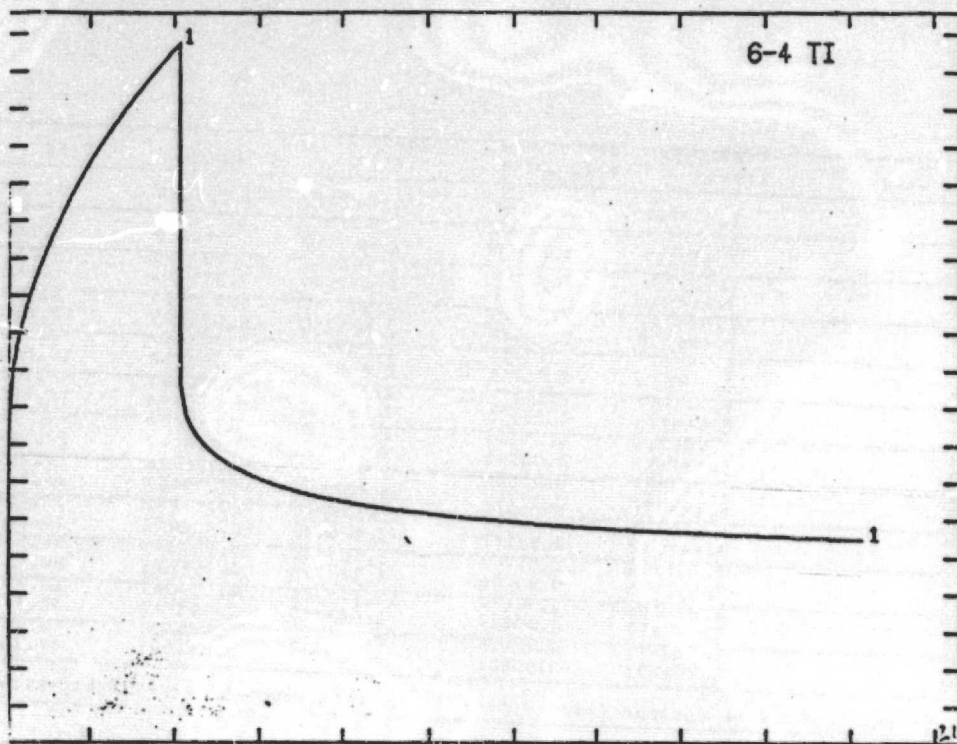


PLOT NUMBER									
6-4 T1 0.5 YIELD/TEMPERATURE= 500 C									
TIME BASE									
TOTAL TIME 222.5 MIN									
RECOVERY AT 43.3 MIN									
INCREMENT OF TIME 1.033 MIN									
INPUT VARIABLES									
LINE	STRESS	CU	CT	CG	CI	CE	EX	LEND	TIME
NUMBER	(PSI)								
1	33503.2	0.1966E-02	0.1255E-07	1.1500	1.8259	1.0390	0.53605	0.17691E-32	40.30000
2	0.700E-02								
3	0.650E-02								
4	0.600E-02								
5	0.550E-02								
6	0.500E-02								
7	0.450E-02								
8	0.400E-02								
9	0.350E-02								
10	0.300E-02								
11	0.250E-02								
12	0.200E-02								
13	0.150E-02								
14	0.100E-02								
15	0.500E-03								
16	0.								
17	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0
18	200.0	220.0							

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	1.702744	0.01164	1.707233	-0.023664	0.160000
2	2.009340	0.00580	2.022730	-0.012902	1.180000
3	2.237218	0.00507	2.255850	-0.018632	3.160000
4	2.361354	0.00452	2.388450	-0.027096	4.880000
5	2.466166	0.00474	2.477630	-0.011464	6.160000
6	2.515365	0.00468	2.501730	0.013635	8.180000
7	2.695739	0.00454	2.695740	-0.000001	10.160000
8	2.792377	0.00438	2.789740	0.002637	12.160000
9	2.832449	0.00419	2.879970	-0.047521	14.160000
10	2.965991	0.00397	2.988450	-0.022459	16.180000
11	3.045713	0.00376	3.045400	0.000313	18.160000
12	3.120221	0.00358	3.109320	0.010901	20.160000
13	3.191137	0.00345	3.176990	0.014147	22.160000
14	3.259928	0.00338	3.233390	0.026538	24.180000
15	3.323977	0.00340	3.304320	0.019657	26.160000
16	3.385394	0.00332	3.388740	-0.003346	28.180000
17	3.447032	0.00372	3.440180	0.006852	30.160000
18	3.505506	0.00340	3.507850	-0.002344	32.160000
19	3.562195	0.00346	3.571770	-0.009575	34.160000
20	3.617255	0.00478	3.631920	-0.014665	36.160000
21	3.670817	0.00524	3.684560	-0.013743	38.160000
22	3.722999	0.00574	3.729880	-0.006881	40.160000
23	3.752673	0.00605	3.767270	-0.014597	41.320000
SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I))^2 - \sum(R(I-1))^2)}}$					
SERIAL CORRELATION		RESIDUALS ORDERED ON			
0.66113		CASE NUMBER		21	

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.848956	0.00706	1.857320	0.008364	0.004840
2	1.732933	0.00690	1.737010	-0.004077	0.029040
3	1.661525	0.00371	1.658050	0.003475	0.077440
4	1.580519	0.00342	1.594140	-0.013621	0.150050
5	1.494993	0.00349	1.503900	-0.008907	0.271060
6	1.436999	0.00349	1.426710	0.010289	0.372080
7	1.393291	0.00341	1.394870	-0.001579	0.513070
8	1.360233	0.00316	1.342230	0.018003	0.708300
9	1.300712	0.00288	1.293360	0.007352	0.901910
10	1.269585	0.00262	1.233780	0.035805	1.093320
11	1.243698	0.00240	1.240720	0.002978	1.289130
12	1.222197	0.00223	1.221920	0.000277	1.482760
13	1.203606	0.00215	1.195600	0.008006	1.676360
14	1.187311	0.00212	1.191840	-0.004529	1.873000
15	1.173340	0.00214	1.180560	-0.007220	2.063580
16	1.160723	0.00220	1.173040	-0.012317	2.237190
17	1.149407	0.00229	1.161760	-0.012353	2.450800
18	1.139170	0.00241	1.146730	-0.007560	2.644410
19	1.129852	0.00253	1.142970	-0.013118	2.838020
20	1.121325	0.00267	1.120410	0.000915	3.031630
21	1.113476	0.00231	1.109130	0.004346	3.225240
22	1.106223	0.00293	1.090330	0.015893	3.418390
23	1.099497	0.00309	1.097850	0.001648	3.612460
24	1.093233	0.00323	1.086570	0.006663	3.805070
25	1.088807	0.00334	1.086570	0.002237	3.951280
SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I))^2 - \sum(R(I-1))^2)}}$					
SERIAL CORRELATION		RESIDUALS ORDERED ON			
0.31037		CASE NUMBER		21	



PLOT NUMBER										
6-4 TI 0.30-YIELD/TEMPERATURE= 515 C										
TIME BASE										
TOTAL TIME 202.5 MIN										
RECOVERY AT 49.3 MIN										
INCREMENT OF TIME 1.035 MIN										
INPUT VARIABLES										
LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7	END
NUMBER	(PSI)									
1	17293	0.1097E-02	0.3920E-08	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.380E-02										
0.360E-02										
0.340E-02										
0.320E-02										
0.300E-02										
0.280E-02										
0.260E-02										
0.240E-02										
0.220E-02										
0.200E-02										
0.180E-02										
0.160E-02										
0.140E-02										
0.120E-02										
0.100E-02										
0.080E-02										
0.060E-02										
0.040E-02										
0.020E-02										
0										
20.0 40.0 60.0 80.0 100.0 120.0 140.0 160.0 180.0 200.0 220.0										

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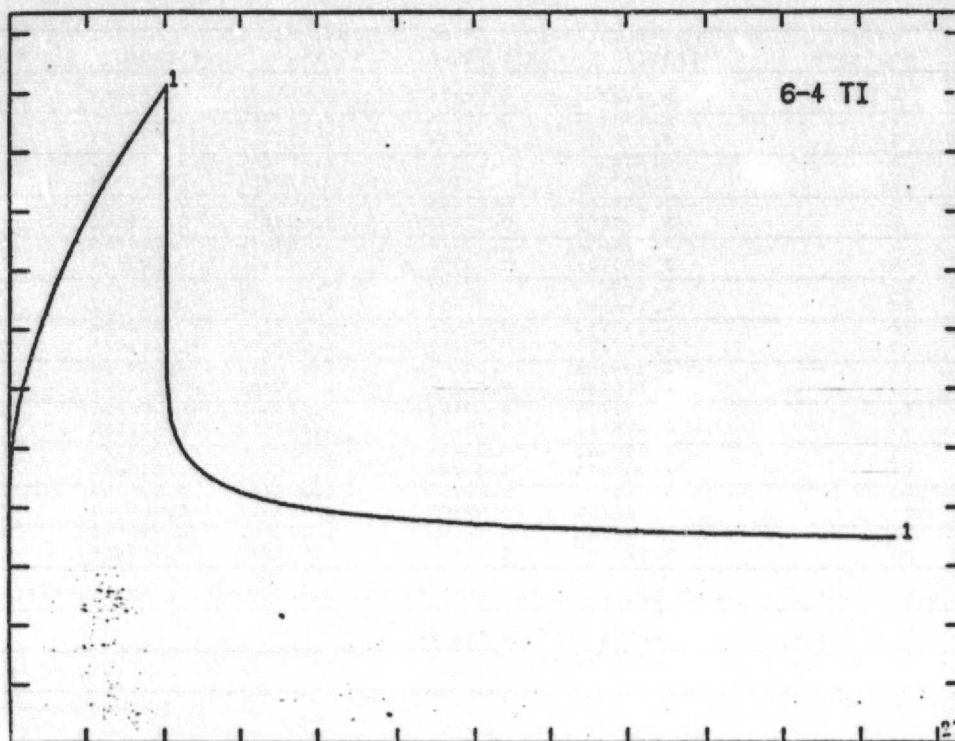
CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		2.267735	0.01271	2.215920	-0.031815	3.120030
2		2.588654	0.00725	2.591340	0.003186	7.120030
3		2.791335	0.00584	2.313430	0.022095	2.120030
4		2.953502	0.00541	2.771710	0.018203	3.120030
5		3.093448	0.00526	3.110210	0.016762	4.120030
6		3.333428	0.00523	3.347630	0.014202	6.120030
7		3.539900	0.00523	3.545440	0.005540	8.120030
8		3.724454	0.00515	3.735410	0.010956	10.120030
9		3.893186	0.00500	3.893690	0.000504	12.120030
10		4.069777	0.00479	4.057730	-0.012047	14.120030
11		4.196667	0.00456	4.182550	-0.014117	16.120030
12		4.333556	0.00434	4.313130	-0.022426	18.120030
13		4.467731	0.00415	4.451530	-0.016201	20.120030
14		4.594355	0.00402	4.574330	-0.019755	22.120030
15		4.715364	0.00396	4.700920	-0.014444	24.120030
16		4.832225	0.00405	4.825960	-0.006265	26.120030
17		4.945124	0.00425	4.938340	-0.006784	28.120030
18		5.054465	0.00455	5.053030	-0.001375	30.120030
19		5.160555	0.00497	5.159930	-0.000625	32.120030
20		5.263771	0.00546	5.270730	0.006959	34.120030
21		5.364269	0.00603	5.373510	0.009341	36.120030
22		5.462274	0.00566	5.480430	0.018156	38.120030
23		5.567485	0.00740	5.537290	0.019635	40.120030
SERIAL CORRELATION OF RESIDUALS= $\sum(R(I) \cdot R(I-1)) / \sqrt{(\sum(R(I))^2) \cdot (\sum(R(I-1))^2)}$						
SERIAL CORRELATION		RESIDUALS ORDERED ON				
0.75359		CASE NUMBER				

21

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1		2.912652	0.02062	2.971710	0.059058	0.007440
2		2.724473	0.01296	2.859110	0.095363	0.032240
3		2.544806	0.01112	2.503740	-0.036066	0.081350
4		2.381934	0.01170	2.334420	-0.007914	0.161050
5		2.200261	0.01107	2.211970	0.011709	0.354660
6		2.078845	0.00931	2.097210	0.018365	0.602680
7		2.035564	0.00784	2.029940	0.024376	0.850690
8		1.955142	0.00881	1.978500	0.023358	1.098710
9		1.917546	0.00615	1.931020	0.013474	1.346730
10		1.888089	0.00579	1.903690	0.017621	1.594740
11		1.864123	0.00565	1.871660	0.007537	1.842760
12		1.844133	0.00566	1.850300	0.006167	2.090770
13		1.827155	0.00578	1.828140	0.000985	2.338790
14		1.812451	0.00596	1.818280	0.005809	2.586310
15		1.799561	0.00618	1.800440	0.000879	2.834820
16		1.788137	0.00642	1.780530	-0.007607	3.082340
17		1.777917	0.00666	1.765620	-0.012297	3.330350
18		1.768701	0.00691	1.757700	-0.011001	3.578370
19		1.760333	0.00715	1.749000	-0.011333	3.826360
20		1.752689	0.00735	1.749000	-0.003689	4.074900
21		1.745668	0.00761	1.741060	-0.004588	4.322920
22		1.739191	0.00783	1.725250	-0.013941	4.570930
23		1.735536	0.00796	1.721300	-0.014236	4.719740
SERIAL CORRELATION OF RESIDUALS= $\sum(R(I) \cdot R(I-1)) / \sqrt{(\sum(R(I))^2) \cdot (\sum(R(I-1))^2)}$						
SERIAL CORRELATION		RESIDUALS ORDERED ON				
0.12974		CASE NUMBER				

21

E 37



PLOT NUMBER
6-4 TI 0.40 YIELD/TEMPERATURE 515 C

TIME BASE
TOTAL TIME 220.3 MIN
RECOVERY AT 40.3 MIN
INCREMENT OF TIME 1.186 MIN

INPUT VARIABLES

LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
NUMBER	(PSI)												
1	25720.0-1623E-32	0.4690E-08	0.950E-08	2.132E-08	1.775E-08	0.5531E-08	0.1475E-08	40.3200	3.1772E-08				
0.630E-02													
0.557E-02													
0.500E-02													
0.450E-02													
0.400E-02													
0.357E-02													
0.330E-02													
0.250E-02													
0.230E-02													
0.150E-02													
0.130E-02													
0.520E-02													
2.													
20.0	40.1	60.1	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0		

ORIGINAL PAGE IS
OF POOR QUALITY

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	3.128423	0.03424	3.021360	-0.107063	0.100000
2	3.433747	0.01975	3.485890	0.052143	1.100000
3	3.713614	0.01604	3.750520	0.036906	2.100000
4	3.694436	0.01422	3.956490	0.262054	3.100000
5	4.354233	0.01423	4.107940	-0.246293	4.100000
6	4.350933	0.01415	4.382610	0.031677	5.100000
7	4.570547	0.01418	4.600730	0.030183	6.100000
8	4.750620	0.01401	4.782300	0.031680	7.100000
9	4.984646	0.01363	4.966310	-0.018336	8.100000
10	5.109825	0.01311	5.140640	0.030815	9.100000
11	5.344009	0.01250	5.307610	-0.036399	10.100000
12	5.539265	0.01189	5.473220	-0.066045	11.100000
13	5.669971	0.01136	5.614590	-0.055381	12.100000
14	5.813176	0.01099	5.776160	-0.037016	13.100000
15	5.963734	0.01086	5.925610	-0.038124	14.100000
16	6.114214	0.01103	6.075070	-0.039144	15.100000
17	6.240246	0.01154	6.220460	-0.019786	16.100000
18	6.372247	0.01238	6.357820	-0.014427	17.100000
19	6.500593	0.01351	6.499190	-0.001403	18.100000
20	6.625604	0.01489	6.644610	0.019006	19.100000
21	6.747556	0.01647	6.777900	0.030344	20.100000
22	6.866687	0.01622	6.915240	0.048553	21.100000
23	6.986965	0.02020	7.044490	0.057525	22.100000

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R(I) \cdot R(I-1))}{\sqrt{(\sum (R(I)^2) \cdot \sum (R(I-1)^2))}}$

SERIAL CORRELATION: RESIDUALS ORDERED ON
0.78727 CASE NUMBER

23

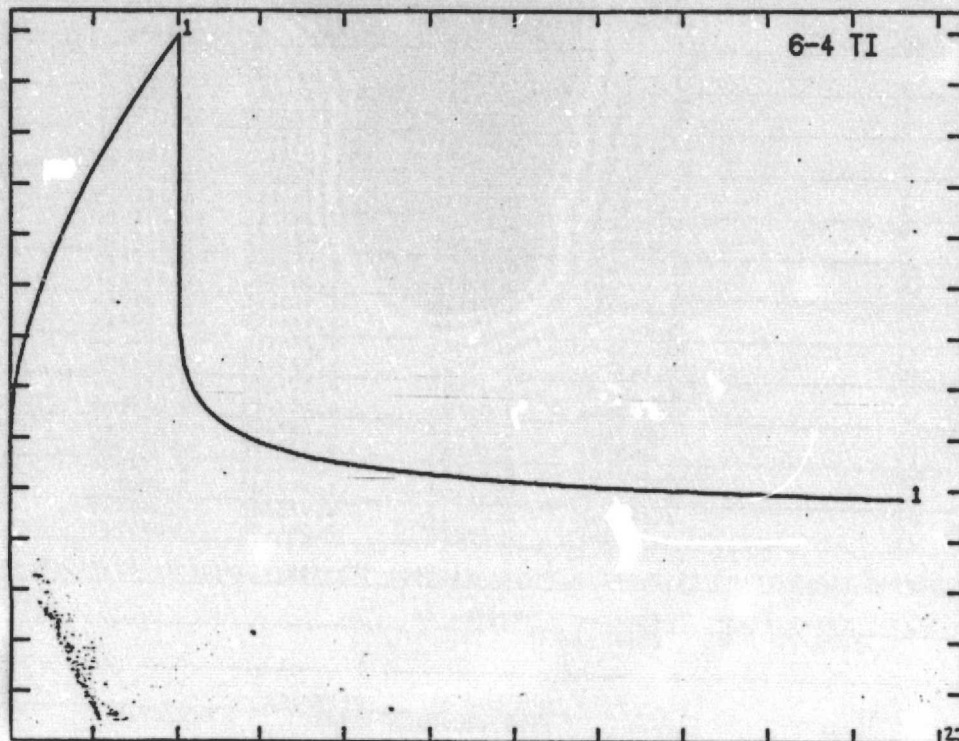
CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	3.666696	0.02172	3.501940	-0.164756	0.009960
2	3.674235	0.01425	3.663620	-0.010615	0.033030
3	3.558899	0.01187	3.533400	-0.025499	0.058710
4	3.424581	0.01104	3.380870	-0.043711	0.104660
5	3.216080	0.01159	3.199110	-0.016970	0.207960
6	3.049574	0.01145	3.037530	-0.012044	0.357210
7	2.911343	0.01035	2.912320	0.000977	0.556220
8	2.839706	0.00942	2.839610	-0.000096	0.705470
9	2.775318	0.00845	2.779020	0.003702	0.879660
10	2.718008	0.00755	2.731550	0.013542	1.078610
11	2.672274	0.00690	2.690160	0.017886	1.277610
12	2.634603	0.00649	2.657040	0.022437	1.476620
13	2.602032	0.00627	2.625530	0.023500	1.675620
14	2.575535	0.00623	2.609370	0.033835	1.874630
15	2.551735	0.00631	2.581100	0.029365	2.073630
16	2.530727	0.00644	2.560700	0.029973	2.272640
17	2.511997	0.00671	2.524590	0.012593	2.471640
18	2.495152	0.00699	2.516470	0.021318	2.670650
19	2.479890	0.00727	2.508390	0.028500	2.869650
20	2.465972	0.00754	2.447860	-0.018112	3.068650
21	2.453210	0.00789	2.407410	-0.045800	3.267660
22	2.441447	0.00819	2.383170	-0.058277	3.466670
23	2.430558	0.00849	2.367010	-0.063548	3.665670
24	2.420437	0.00879	2.403370	0.002933	3.864680
25	2.410997	0.00909	2.419530	0.008533	4.063680
26	2.402163	0.00935	2.423560	0.021397	4.262690

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum (R(I) \cdot R(I-1))}{\sqrt{(\sum (R(I)^2) \cdot \sum (R(I-1)^2))}}$

SERIAL CORRELATION: RESIDUALS ORDERED ON
0.73772 CASE NUMBER

23

239



PLGT NUMBER									
6-4 TI 0.45MPa/TEMPERATURE 515 C									
TIME BASE									
TOTAL TIME 211.3 MIN									
RECOVERY AT 40.2 MIN									
INCREMENT OF TIME 1.055 MIN									
INPUT VARIABLES									
LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	END
NUMBER	(PSI)								
1	21218-72	0.36928-08	1.1966	1.1742	1.6298	0.57736	0.194698-02	40.23333	2.33350
0.7908-02									
0.6508-02									
0.6008-02									
0.5508-02									
0.5008-02									
0.4508-02									
0.4008-02									
0.3508-02									
0.3008-02									
0.2508-02									
0.2008-02									
0.1508-02									
0.1008-02									
0.0508-02									
0.									
20.2	40.2	60.2	80.2	100.2	120.2	140.2	160.2	180.2	200.2

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CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		3.426142	0.17392	3.279670	-0.146472	0.100000
2		3.787993	0.10579	3.813060	0.025067	1.100000
3		4.013770	0.08704	4.086970	0.073200	2.100000
4		4.351623	0.07712	4.469000	0.117377	3.100000
5		4.687373	0.07557	4.778940	0.091565	4.100000
6		4.939397	0.07550	5.043640	0.104243	5.100000
7		5.208127	0.07480	5.297920	0.089793	10.100000
8		5.439563	0.07311	5.514170	0.074607	12.100000
9		5.657680	0.07056	5.723200	0.065520	14.100000
10		5.864752	0.06764	5.932230	0.067478	16.100000
11		6.063267	0.06411	6.126850	-0.063583	18.100000
12		6.253363	0.06039	6.314280	0.060917	20.100000
13		6.437930	0.05356	6.487250	0.049320	22.100000
14		6.615379	0.05729	6.683130	0.067751	24.100000
15		6.788753	0.05762	6.833240	0.044487	26.100000
16		6.956953	0.05783	7.013640	0.056687	28.100000
17		7.120940	0.06398	7.150400	0.029460	30.100000
18		7.281075	0.06793	7.314740	0.033665	32.100000
19		7.445428	0.07784	7.467530	0.022102	34.200000
20		7.596636	0.08369	7.618920	0.022284	36.200000
21		7.748850	0.09657	7.763080	0.014230	38.200000
22		7.912333	0.10350	7.950490	0.038157	40.200000

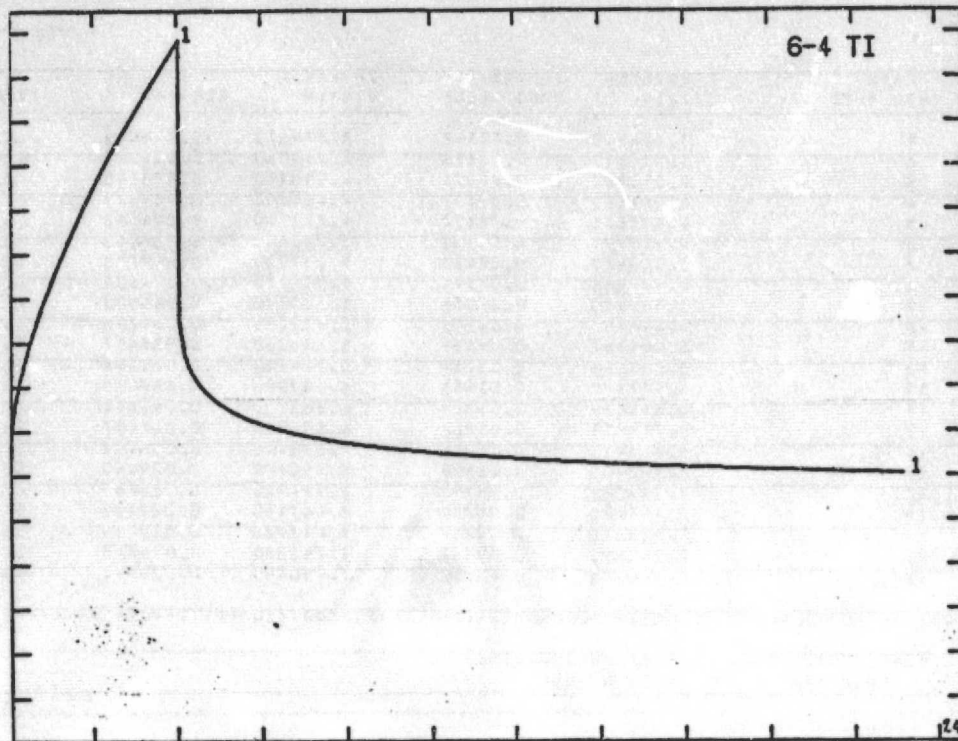
SERIAL CORRELATION OF RESIDUALS = $\text{SUM}(R(I) * R(I-1)) / \text{SQRT}(\text{SUM}(R(I)**2) * \text{SUM}(R(I-1)**2))$

SERIAL CORRELATION -0.06413 RESIDUALS ORDERED ON CASE NUMBER 24

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		4.605123	0.00983	4.627570	0.022447	0.003440
2		4.357563	0.00812	4.339250	-0.018313	0.003130
3		4.138024	0.00510	4.123010	-0.015014	0.003660
4		3.944887	0.00323	3.930020	-0.014867	0.003180
5		3.729223	0.00512	3.740980	0.011757	0.003330
6		3.552760	0.00442	3.557100	0.004340	0.003000
7		3.454613	0.00382	3.452660	-0.001953	0.002910
8		3.383542	0.00333	3.357790	-0.025752	0.002330
9		3.328699	0.00301	3.310120	-0.018579	1.113750
10		3.284531	0.00278	3.273680	-0.010851	1.116870
11		3.247916	0.00264	3.250830	0.002914	1.114600
12		3.216819	0.00258	3.229210	0.012391	1.112520
13		3.189947	0.00258	3.193170	0.003223	1.110440
14		3.168373	0.00262	3.171350	0.002977	2.108380
15		3.145503	0.00270	3.157130	0.011627	2.106280
16		3.126793	0.00279	3.121090	-0.005703	2.104210
17		3.109896	0.00289	3.102350	-0.007546	2.102130
18		3.094527	0.00300	3.077840	-0.016687	2.100050
19		3.080462	0.00311	3.070630	-0.009831	3.097970
20		3.067517	0.00323	3.059100	-0.008417	3.095890
21		3.055549	0.00334	3.041800	-0.013749	3.093810
22		3.044433	0.00345	3.038920	-0.005513	3.091730
23		3.034072	0.00356	3.038920	0.004848	3.089650
24		3.024580	0.00366	3.033150	0.008570	4.087530
25		3.017506	0.00376	3.028630	0.011124	4.236020

SERIAL CORRELATION OF RESIDUALS = $\text{SUM}(R(I) * R(I-1)) / \text{SQRT}(\text{SUM}(R(I)**2) * \text{SUM}(R(I-1)**2))$

SERIAL CORRELATION 0.23273 RESIDUALS ORDERED ON CASE NUMBER 24



PLOT NUMBER									
6-4 TI 0.50=YIELD/TEMPERATURE= 515 C									
TIME BASE									
TOTAL TIME 211.7 MIN									
RECOVERY AT 40.6 MIN									
INCREMENT OF TIME 1.566 MIN									
INPUT VARIABLES									
LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	END
NUMBER	(PSI)								
1	32150.0	0.2295E-02	0.3690E-08	1.2020	1.9970	1.7187	0.6430E-02	0.24031E-32	40.42000
2	0.850E-02								
3	0.750E-02								
4	0.700E-02								
5	0.650E-02								
6	0.600E-02								
7	0.550E-02								
8	0.500E-02								
9	0.450E-02								
10	0.400E-02								
11	0.350E-02								
12	0.300E-02								
13	0.250E-02								
14	0.200E-02								
15	0.150E-02								
16	0.100E-02								
17	0.050E-02								
18	0.000E-02								
19	0.000E-02								
20	0.000E-02								
21	0.000E-02								
22	0.000E-02								
23	0.000E-02								
24	0.000E-02								
25	0.000E-02								
26	0.000E-02								
27	0.000E-02								
28	0.000E-02								
29	0.000E-02								
30	0.000E-02								
31	0.000E-02								
32	0.000E-02								
33	0.000E-02								
34	0.000E-02								
35	0.000E-02								
36	0.000E-02								
37	0.000E-02								
38	0.000E-02								
39	0.000E-02								
40	0.000E-02								
41	0.000E-02								
42	0.000E-02								
43	0.000E-02								
44	0.000E-02								
45	0.000E-02								
46	0.000E-02								
47	0.000E-02								
48	0.000E-02								
49	0.000E-02								
50	0.000E-02								
51	0.000E-02								
52	0.000E-02								
53	0.000E-02								
54	0.000E-02								
55	0.000E-02								
56	0.000E-02								
57	0.000E-02								
58	0.000E-02								
59	0.000E-02								
60	0.000E-02								
61	0.000E-02								
62	0.000E-02								
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64	0.000E-02								
65	0.000E-02								
66	0.000E-02								
67	0.000E-02								
68	0.000E-02								
69	0.000E-02								
70	0.000E-02								
71	0.000E-02								
72	0.000E-02								
73	0.000E-02								
74	0.000E-02								
75	0.000E-02								
76	0.000E-02								
77	0.000E-02								
78	0.000E-02								
79	0.000E-02								
80	0.000E-02								
81	0.000E-02								
82	0.000E-02								
83	0.000E-02								
84	0.000E-02								
85	0.000E-02								
86	0.000E-02								
87	0.000E-02								
88	0.000E-02								
89	0.000E-02								
90	0.000E-02								
91	0.000E-02								
92	0.000E-02								
93	0.000E-02								
94	0.000E-02								
95	0.000E-02								
96	0.000E-02								
97	0.000E-02								
98	0.000E-02								
99	0.000E-02								
100	0.000E-02								

ORIGINAL PAGE IS
OF POOR QUALITY

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.070623	0.00613	2.079360	0.008737	0.133000
2	2.317684	0.00322	2.305400	-0.012284	1.133000
3	2.450047	0.00252	2.437810	-0.012237	2.133000
4	2.551210	0.00225	2.550740	-0.000470	3.133000
5	2.635889	0.00214	2.636410	0.000521	4.133000
6	2.709983	0.00210	2.710410	0.000427	5.133000
7	2.776557	0.00207	2.776610	0.000053	6.133000
8	2.837441	0.00206	2.850600	0.013159	7.133000
9	2.893829	0.00206	2.897330	0.003501	8.133000
10	2.946551	0.00202	2.951850	0.005299	9.133000
11	2.996212	0.00199	2.998580	0.002368	10.133000
12	3.043268	0.00196	3.049210	0.005942	11.133000
13	3.088073	0.00193	3.088150	0.000077	12.133000
14	3.171958	0.00186	3.169930	-0.002028	14.133000
15	3.249670	0.00179	3.247810	-0.001860	16.133000
16	3.322252	0.00173	3.317910	-0.004342	18.133000
17	3.390550	0.00169	3.395800	0.005250	20.133000
18	3.455319	0.00168	3.454210	-0.001109	22.133000
19	3.516936	0.00170	3.504860	-0.012076	24.133000
20	3.575824	0.00175	3.563250	-0.012574	26.133000
21	3.632366	0.00185	3.629650	-0.002716	28.133000
22	3.686640	0.00197	3.687870	0.001230	30.133000
23	3.739062	0.00213	3.746280	0.007218	32.133000
24	3.789695	0.00231	3.793010	0.003315	34.133000
25	3.838755	0.00251	3.843660	0.004905	36.133000
26	3.886357	0.00272	3.898160	0.011803	38.133000
27	3.932617	0.00295	3.933200	0.000583	40.133000
28	3.957525	0.00308	3.944890	-0.012635	41.233000

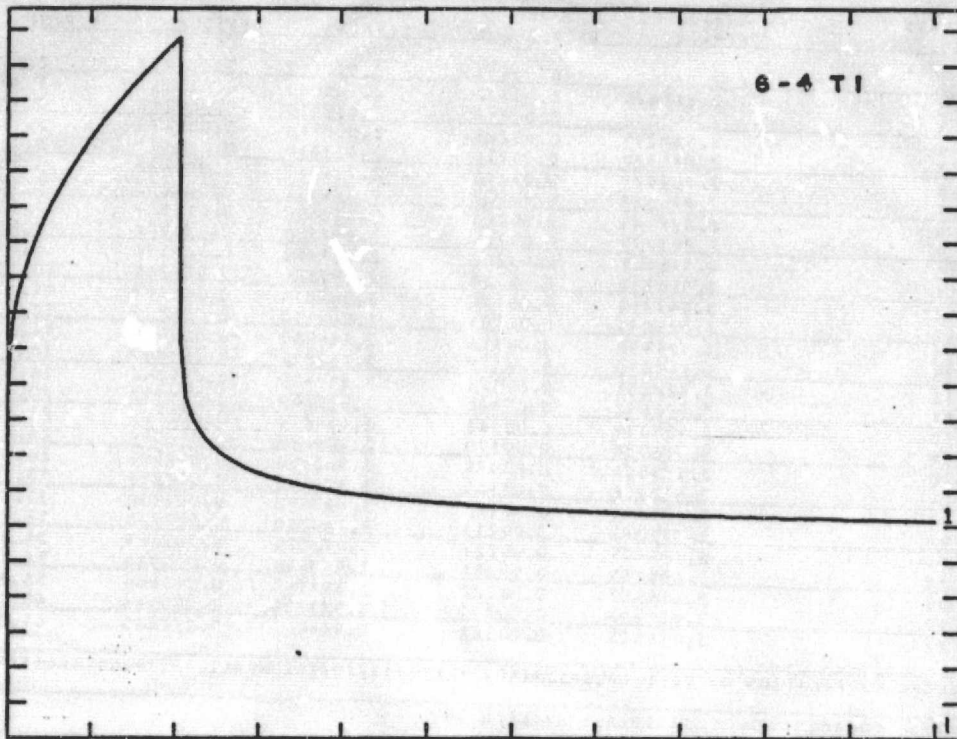
SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.33563 RESIDUALS ORDERED ON CASE NUMBER

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	1.845551	0.00989	1.845880	0.000329	0.053360
2	1.789036	0.00736	1.791360	0.002324	0.077610
3	1.710028	0.00509	1.709580	-0.000448	0.126110
4	1.654699	0.00446	1.651170	-0.003529	0.174620
5	1.612549	0.00436	1.612220	-0.000329	0.223120
6	1.578813	0.00438	1.577180	-0.001633	0.271650
7	1.550928	0.00439	1.542130	-0.008798	0.320130
8	1.516726	0.00434	1.518760	0.001974	0.392890
9	1.489180	0.00424	1.487610	-0.001570	0.465650
10	1.459397	0.00406	1.464240	0.004843	0.562660
11	1.435276	0.00387	1.440880	0.005604	0.659670
12	1.415215	0.00370	1.433090	0.017875	0.756680
13	1.406372	0.00362	1.409720	0.003348	0.805180
14	1.376867	0.00339	1.366890	-0.009977	0.999200
15	1.354054	0.00329	1.378570	0.024476	1.193220
16	1.335835	0.00331	1.331840	-0.003995	1.387240
17	1.320777	0.00341	1.320150	-0.000627	1.581260
18	1.308088	0.00356	1.285110	-0.022978	1.775280
19	1.292319	0.00383	1.253950	-0.038369	2.066310
20	1.272028	0.00432	1.269530	-0.002498	2.551350
21	1.253986	0.00487	1.269530	0.015544	3.133610
22	1.242321	0.00528	1.261740	0.019419	3.618460
23	1.232750	0.00564	1.238380	0.005630	4.103510
24	1.229376	0.00577	1.222800	-0.006576	4.297530

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I) \cdot R(I-1)) / \text{SQRT}(\text{SUM}(R(I)^2) \cdot \text{SUM}(R(I-1)^2))$

SERIAL CORRELATION 0.29116 RESIDUALS ORDERED ON CASE NUMBER



PLOT NUMBER									
6-4 T1 0.3 X1000 TEMPERATURE= 350 C									
TIME BASE									
TOTAL TIME 220.0 MIN									
RECOVERY AT 41.3 MIN									
INCREMENT OF TIME 1.257 MIN									
INPUT VARIABLES									
LINE	STRESS	CU	CT	GU	GI	GE	EN	CEYS	TIME
NUMBER	(PSI)								
1	18283.3	1151E-02	0.1776E-07	1.0000	1.7701	1.0000	0.45511	0.1C939E-02	41.25300
0.400E-02									
0.380E-02									
0.360E-02									
0.340E-02									
0.320E-02									
0.300E-02									
0.280E-02									
0.260E-02									
0.240E-02									
0.220E-02									
0.200E-02									
0.180E-02									
0.160E-02									
0.140E-02									
0.120E-02									
0.100E-02									
0.800E-03									
0.600E-03									
0.400E-03									
0.200E-03									
0.									
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		2.724974	0.01934	2.683070	-0.041804	0.167000
2		3.086883	0.01099	3.102290	0.015402	1.167000
3		3.300374	0.00848	3.315720	0.015346	2.167000
4		3.468727	0.00737	3.483410	0.014683	3.167000
5		3.612440	0.00685	3.628240	0.015800	4.167000
6		3.740010	0.00662	3.750190	0.010180	5.167000
7		3.855940	0.00652	3.864530	0.008590	6.167000
8		3.962959	0.00647	3.975050	0.012091	7.167000
9		4.062872	0.00643	4.066520	0.003648	8.167000
10		4.156942	0.00640	4.165610	0.008668	9.167000
11		4.246100	0.00636	4.245650	-0.000450	10.167000
12		4.331050	0.00631	4.333500	0.002250	11.167000
13		4.412343	0.00626	4.413340	0.000997	12.167000
14		4.490420	0.00620	4.497180	0.006760	13.167000
15		4.565639	0.00614	4.573400	0.007761	14.167000
16		4.638255	0.00607	4.642010	0.003715	15.167000
17		4.708638	0.00603	4.710610	0.001972	16.167000
18		4.843191	0.00594	4.844000	0.000809	18.167000
19		4.970654	0.00595	4.912600	-0.058054	20.167000
20		5.092053	0.00605	5.049800	-0.042253	22.167000
21		5.264486	0.00639	5.221310	-0.043176	25.167000
22		5.530819	0.00750	5.507150	-0.023669	30.167000
23		5.776241	0.00917	5.762490	-0.013751	35.167000
24		6.005063	0.01121	6.029280	0.024217	40.167000
25		6.049117	0.01165	6.082630	0.033513	41.167000
26		6.053453	0.01169	6.090250	0.036797	41.267000

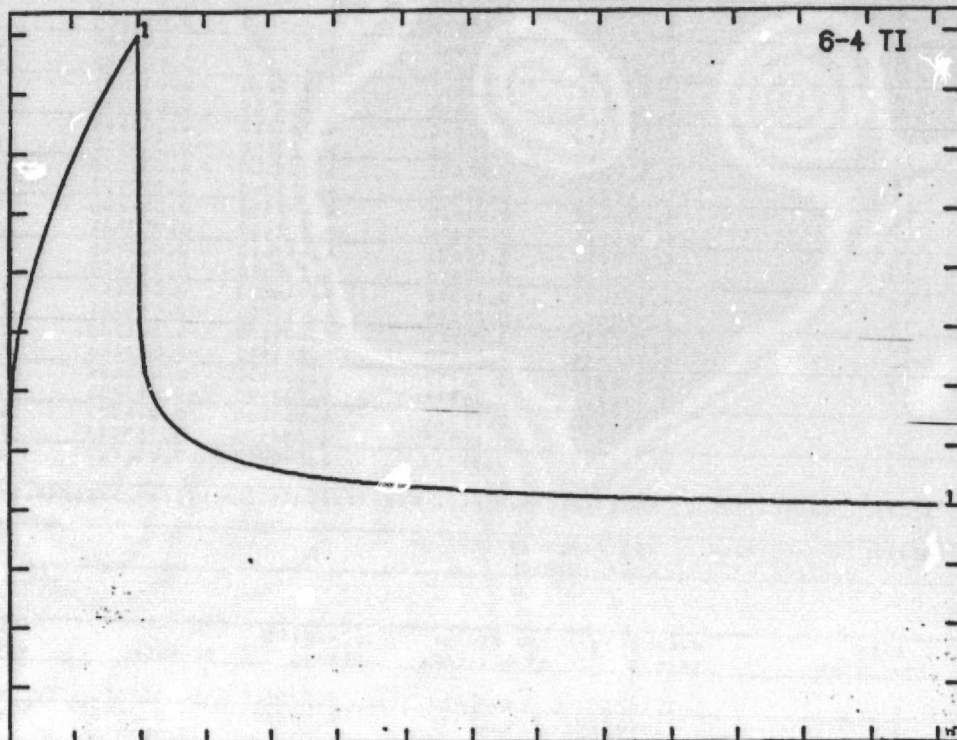
SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)*R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)*\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION 0.62846 RESIDUALS ORDERED ON CASE NUMBER 15

CASE NO.	NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		3.077330	0.00488	3.075620	-0.001710	0.053310
2		2.996532	0.00375	2.999390	0.002858	0.077540
3		2.932684	0.00305	2.930790	-0.001894	0.101780
4		2.879789	0.00261	2.873620	-0.006169	0.126010
5		2.836615	0.00236	2.827890	-0.008725	0.150240
6		2.795227	0.00221	2.789780	-0.005447	0.174470
7		2.729052	0.00213	2.732610	0.003518	0.222940
8		2.675065	0.00214	2.686880	0.011815	0.271400
9		2.629558	0.00218	2.641160	0.011542	0.319370
10		2.572923	0.00222	2.583980	0.011057	0.392570
11		2.526244	0.00223	2.530620	0.004376	0.465260
12		2.486819	0.00222	2.488700	0.001881	0.537960
13		2.452853	0.00219	2.450580	-0.002313	0.610660
14		2.423267	0.00215	2.416280	-0.006987	0.683350
15		2.397077	0.00210	2.401060	0.003963	0.756050
16		2.373656	0.00205	2.378170	0.004474	0.828750
17		2.339723	0.00194	2.347680	0.007957	0.949910
18		2.310665	0.00191	2.298140	-0.012525	1.071070
19		2.285425	0.00186	2.271660	-0.013765	1.192240
20		2.243502	0.00180	2.225730	-0.017772	1.434560
21		2.209837	0.00179	2.202860	-0.006977	1.676880
22		2.158512	0.00187	2.160940	0.002428	2.161530
23		2.120659	0.00203	2.119010	-0.001689	2.646180
24		2.091332	0.00222	2.088520	-0.002812	3.130830
25		2.067462	0.00260	2.077090	0.009628	3.615480
26		2.048053	0.00257	2.042790	-0.005263	4.100130
27		2.031459	0.00273	2.031360	-0.000099	4.584780
28		2.017177	0.00288	2.027540	0.010363	5.069630
29		2.004715	0.00301	2.008490	0.003775	5.554070
30		1.997959	0.00369	2.000870	0.002911	5.844860

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)*R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)*\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION 0.51309 RESIDUALS ORDERED ON CASE NUMBER 15



PLOT NUMBER									
6-4 TI 0.4 YIELD TEMPERATURE= 550 C									
TIME BASE									
TOTAL TIME 279.7 MIN									
RECOVERY AT 39.8 MIN									
INCREMENT OF TIME 1.420 MIN									
INPUT VARIABLES									
LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	ENT
NUMBER	(PSI)								
1	24375.0	184646-020	177628-070	980001	918600	901703	109100	171968-32	41.26700 1.96354
0.600E-02									
0.110E-02									
0.300E-02									
0.410E-02									
0.400E-02									
0.110E-02									
0.300E-02									
0.210E-02									
0.200E-02									
0.110E-02									
0.100E-02									
0.100E-03									
0.									
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0 220.0 240.0 260.0 280.0

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	5.255417	0.03125	5.181720	-0.097423	0.100000
2	5.075375	0.11362	5.217440	0.135134	1.100000
3	5.412131	0.01547	5.484970	0.056779	2.100000
4	4.317727	0.01335	4.371140	0.058463	4.100000
5	4.619133	0.01256	4.664760	0.044427	6.100000
6	4.592735	0.11264	4.912240	0.350305	8.100000
7	5.120504	0.01271	5.124670	0.009164	10.100000
8	5.333314	0.11247	5.337140	-0.001857	12.100000
9	5.542155	0.01207	5.531740	-0.010415	14.100000
10	5.733475	0.11176	5.712470	-0.021445	16.100000
11	5.914869	0.01164	5.926150	0.011281	18.100000
12	6.087469	0.01151	6.053900	-0.037969	20.100000
13	6.233649	0.11003	6.219730	-0.033919	22.100000
14	6.413126	0.00765	6.374570	-0.033556	24.100000
15	6.582034	0.00941	6.532460	-0.049574	26.100000
16	6.715374	0.00335	6.675350	-0.040024	28.100000
17	6.860443	0.00453	6.832230	-0.028213	30.100000
18	7.000369	0.00767	6.977220	-0.023649	32.100000
19	7.132595	0.01157	7.116210	-0.021385	34.100000
20	7.270932	0.01141	7.262150	-0.008782	36.100000
21	7.401146	0.01243	7.408070	0.006944	38.100000
22	7.528463	0.01359	7.547070	0.018602	40.100000
23	7.657101	0.01489	7.686060	0.032459	42.100000
24	7.775227	0.01627	7.825050	0.049823	44.100000
25	7.781271	0.01634	7.832000	0.050729	46.200000

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)*R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)*\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION 0.54383 RESIDUALS ORDERED ON CASE NUMBER

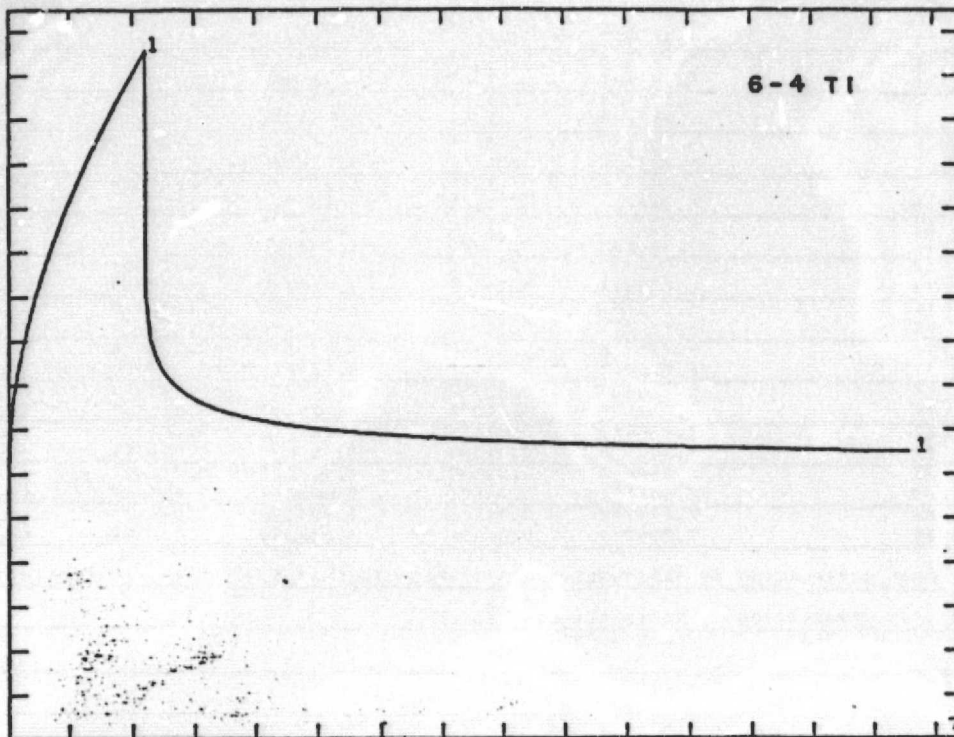
7

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	4.937162	0.02373	4.975790	0.038628	0.001130
2	4.389478	0.01314	4.386620	-0.002858	0.023760
3	4.436552	0.01195	4.343390	-0.093162	0.046380
4	4.130175	0.01248	4.127760	-0.002215	0.136880
5	3.973712	0.01224	3.988970	0.015258	0.227380
6	3.893698	0.01175	3.919470	0.025772	0.295250
7	3.553677	0.00908	3.697090	0.033413	0.657240
8	3.552652	0.00754	3.576170	0.023318	1.019230
9	3.483715	0.00683	3.499730	0.016015	1.381220
10	3.435084	0.00662	3.439960	0.004876	1.743210
11	3.398374	0.00666	3.398270	-0.000104	2.105200
12	3.369338	0.00685	3.367690	-0.001648	2.467190
13	3.345591	0.00709	3.342670	-0.002921	2.829190
14	3.325680	0.00736	3.321320	-0.004360	3.191180
15	3.308657	0.00764	3.300960	-0.007677	3.553170
16	3.293875	0.00790	3.287080	-0.006795	3.915160
17	3.280875	0.00816	3.273180	-0.007695	4.277150
18	3.269320	0.00841	3.259280	-0.010040	4.639140
19	3.258955	0.00864	3.249550	-0.009405	5.001130
20	3.249587	0.00886	3.245380	-0.004207	5.363120
21	3.243122	0.00901	3.238430	-0.004692	5.634620

SERIAL CORRELATION OF RESIDUALS= $\text{SUM}(R(I)*R(I-1))/\text{SQRT}(\text{SUM}(R(I)**2)*\text{SUM}(R(I-1)**2))$

SERIAL CORRELATION J.25225 RESIDUALS ORDERED ON CASE NUMBER

7



PLOT NUMBER									
6-4 TI 0.15 TILD/TEMPERATURE= 530 C									
TIME BASE									
TOTAL TIME 291.7 MIN									
RECOVERY AT 44.2 MIN									
INCREMENT OF TIME 1.473 MIN									
INPUT VARIABLES									
LINE NUMBER	STRESS (PSI)	CU	CT	GU	GT	GT	EX	CEM	TORE
1	27421.3	2095E-02	0.1776E-07	1.0820	2.2270	1.1060	0.57237	0.29335E-02	44.20000
0.800E-02									
0.750E-02									
0.700E-02									
0.650E-02									
0.600E-02									
0.550E-02									
0.500E-02									
0.450E-02									
0.400E-02									
0.350E-02									
0.300E-02									
0.250E-02									
0.200E-02									
0.150E-02									
0.100E-02									
0.500E-03									
0.									
20.0	40.0	50.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
220.0	240.0	260.0	280.0	300.0	320.0				

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	3.925951	0.02099	3.761450	-0.064491	1.200000
2	4.056459	0.01570	4.051370	-0.005129	2.200000
3	4.256156	0.01269	4.266920	0.012764	3.200000
4	4.432407	0.01100	4.445360	0.012953	4.200000
5	4.597270	0.01015	4.616340	0.019070	5.200000
6	4.752055	0.00982	4.779880	0.027785	6.200000
7	5.039354	0.00990	5.077230	0.037836	8.200000
8	5.304557	0.01022	5.337410	0.032812	10.200000
9	5.553343	0.01044	5.582720	0.029377	12.200000
10	5.789144	0.01045	5.798300	0.009156	14.200000
11	6.014378	0.01028	6.013870	-0.000508	16.200000
12	6.230747	0.00997	6.214580	-0.016167	18.200000
13	6.439524	0.00955	6.422730	-0.016794	20.200000
14	6.641652	0.00911	6.618000	-0.023652	22.200000
15	6.838030	0.00972	6.809280	-0.028750	24.200000
16	7.029170	0.00846	7.002560	-0.026610	26.200000
17	7.215630	0.00842	7.180970	-0.034660	28.200000
18	7.397847	0.00868	7.359380	-0.038467	30.200000
19	7.576150	0.00927	7.552650	-0.023500	32.200000
20	7.750974	0.01019	7.731060	-0.019914	34.200000
21	7.922472	0.01139	7.909470	-0.013002	36.200000
22	8.090923	0.01284	8.110180	0.019257	38.200000
23	8.256537	0.01448	8.310890	0.054353	40.200000
24	8.349170	0.01548	8.407530	0.058360	41.333300

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{\sum(R(I))^2 \cdot \sum(R(I-1))^2}}$

SERIAL CORRELATION 0.79613 RESIDUALS ORDERED ON CASE NUMBER

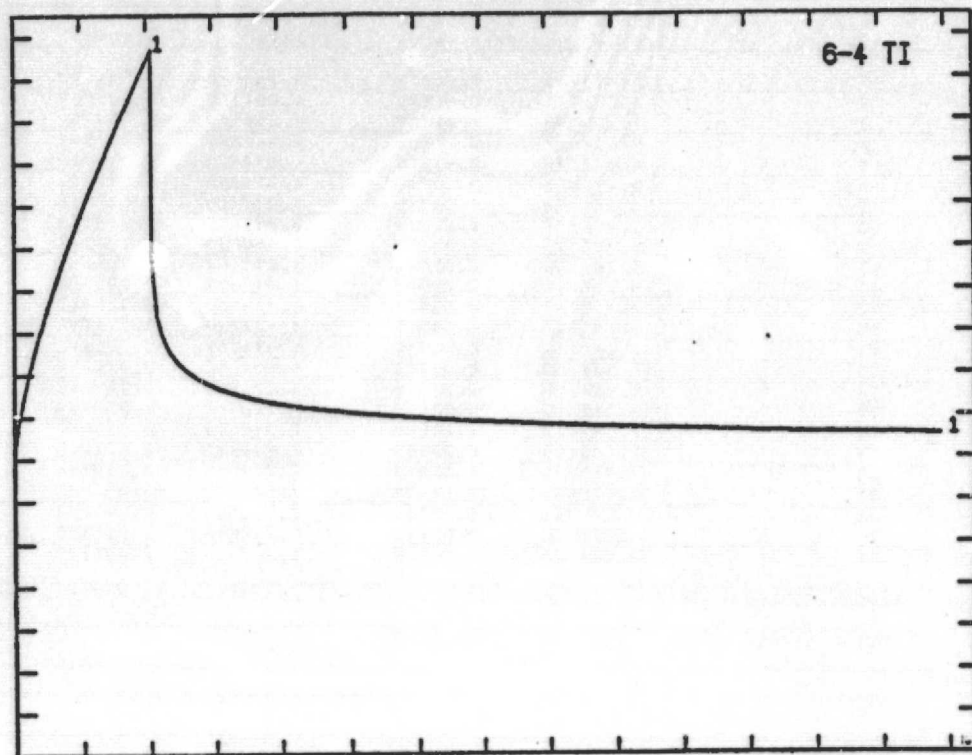
16

CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	4.961331	0.01935	4.935980	-0.025351	0.077429
2	4.486151	0.01175	4.504830	0.018679	0.295160
3	4.229259	0.00935	4.217220	-0.007952	0.582260
4	4.160820	0.00817	4.170310	0.009490	0.875810
5	4.067835	0.00645	4.066240	-0.001595	1.262910
6	4.019108	0.00566	4.021640	0.002532	1.553240
7	3.980814	0.00522	3.954730	-0.026084	1.863560
8	3.949572	0.00504	3.910130	-0.039442	2.133890
9	3.923381	0.00505	3.895270	-0.028111	2.424210
10	3.900961	0.00518	3.902700	0.001739	2.714540
11	3.881453	0.00539	3.880400	-0.001053	3.004950
12	3.864250	0.00564	3.872960	0.008710	3.295190
13	3.839564	0.00517	3.850560	0.011096	3.779050
14	3.818690	0.00657	3.835800	0.017110	4.262940
15	3.857701	0.00703	3.791190	-0.066511	4.756810
16	3.784965	0.00746	3.783760	-0.001205	5.230690
17	3.771027	0.00786	3.806060	0.035033	5.714560

SERIAL CORRELATION OF RESIDUALS= $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{\sum(R(I))^2 \cdot \sum(R(I-1))^2}}$

SERIAL CORRELATION 0.46864 RESIDUALS ORDERED ON CASE NUMBER

16



PLOT NUMBER										
6-4 TI 0.5 YIELD TEMPERATURE= 330 C										
TIME BASE										
TOTAL TIME 277.6 MIN										
RECOVERY AT 41.3 MIN										
INCREMENT OF TIME 1.425 MIN										
INPUT VARIABLES										
LINE NUMBER	STRESS (PSI)	C0	C1	C0	ST	Y02	ST	CEND	YONE	END
1	30470.0.25300E-020.17762E-071.053001.967901.603003.675720.32670E-32	41.3330C	8.480E6							
0.850E-02										
0.800E-02										
0.750E-02										
0.700E-02										
0.650E-02										
0.600E-02										
0.550E-02										
0.500E-02										
0.450E-02										
0.400E-02										
0.350E-02										
0.300E-02										
0.250E-02										
0.200E-02										
0.150E-02										
0.100E-02										
0.050E-02										
0.										
20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0
240.0	260.0	280.0								

Table 6. Parameters for Ti-6Al-4V Titanium Alloy

Temperature (°C)	Stress (MPa)	A(0) (10 ⁻⁶)	r ₁ (10 ⁻⁹)	g ₀	g ₁	g ₂
440	0.3	9.18426	4.18372	1.00	1.6693	1.00
440	0.4			0.9464	1.515	1.388
440	0.45			0.8531	1.6208	1.3676
440	0.5			0.8656	1.4115	1.489
470	0.3	8.17268	3.23034	1.00	1.4098	1.00
470	0.4			1.095	1.296	2.761
470	0.45			1.0827	1.563	2.263
470	0.5			1.0645	1.456	2.933
485	0.3	8.4582	4.24981	1.00	1.5905	1.00
485	0.4			1.0356	1.4887	1.5559
485	0.45			0.9397	1.6121	1.956
485	0.5			1.1854	1.4146	3.9955
500	0.3	7.76	12.55166	1.00	1.6332	1.00
500	0.4			1.186	1.4836	0.6604
500	0.45			1.1639	2.0361	0.6271
500	0.5			1.15	1.8259	1.039
515	0.3	8.6165	8.6897	1.00	1.906	1.00
515	0.4			0.9506	2.132	1.7956
515	0.45			1.1966	1.884	1.6288
515	0.5			1.202	1.997	1.7186
530	0.3	10.5087	17.76189	1.00	1.7701	1.00
530	0.4			0.98	1.9186	0.9037
530	0.45			1.082	2.227	1.106
530	0.5			1.053	1.9679	1.603

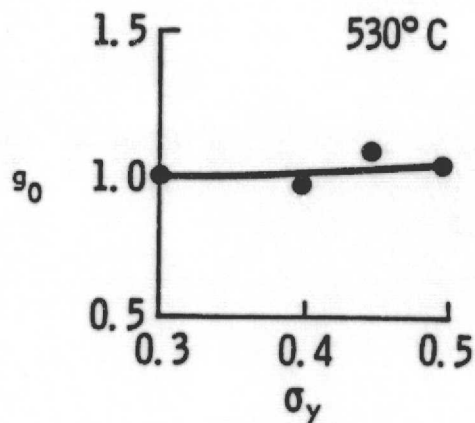
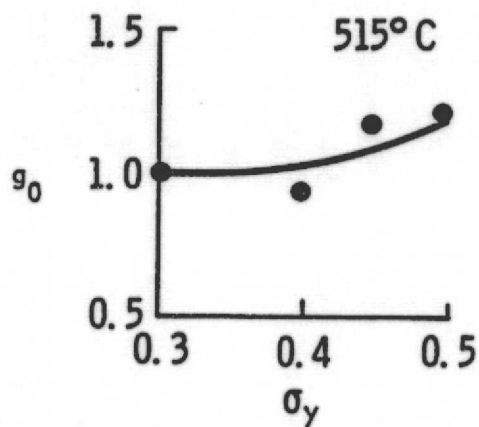
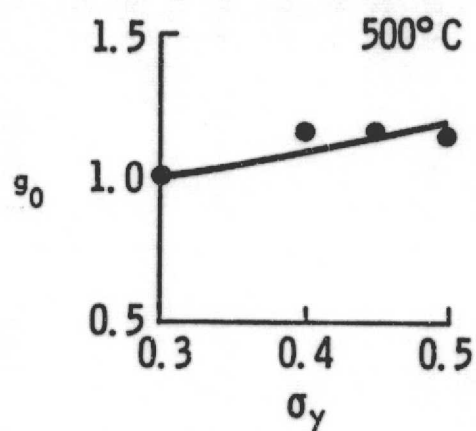
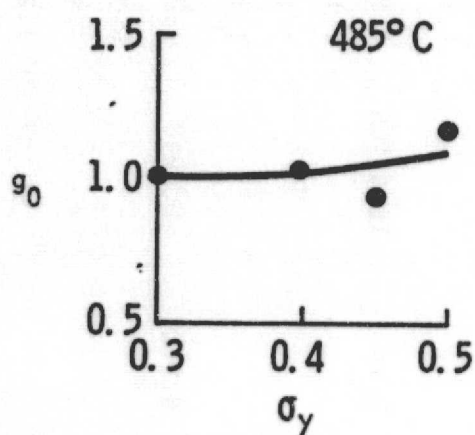
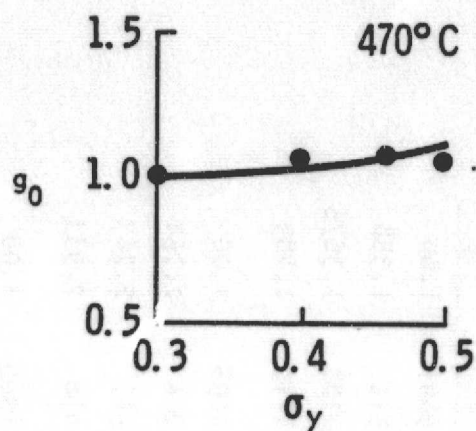
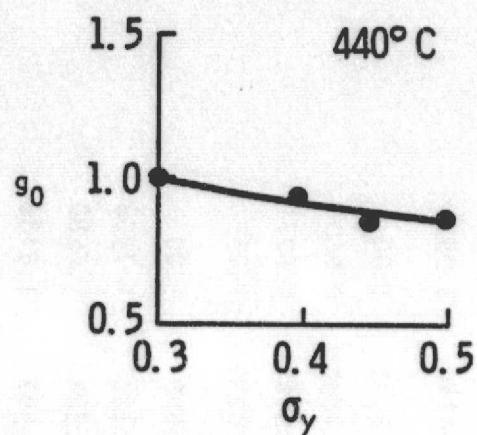


Figure 12. Variation of g_0 with stress (constant temperature) in Ti-6Al-4V.

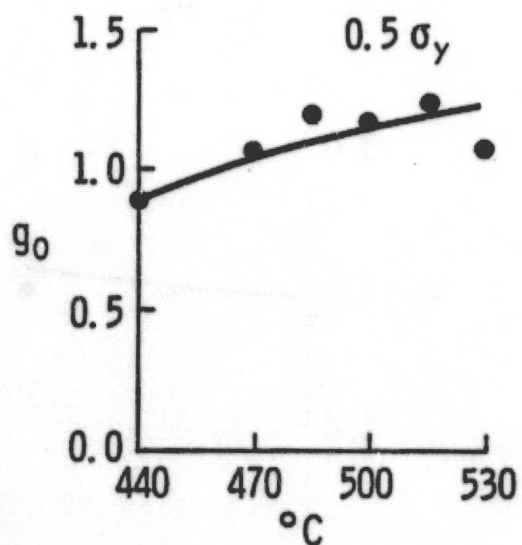
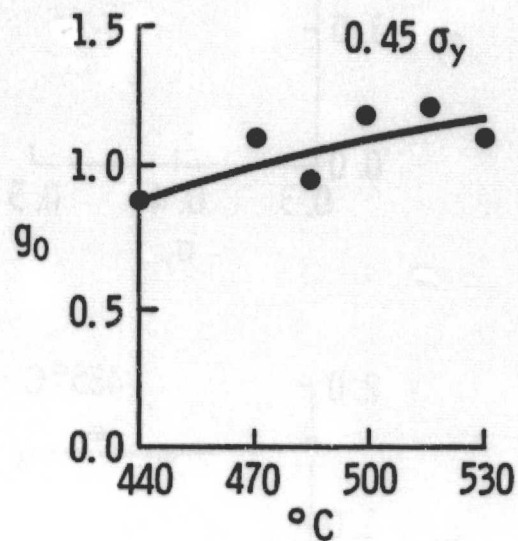
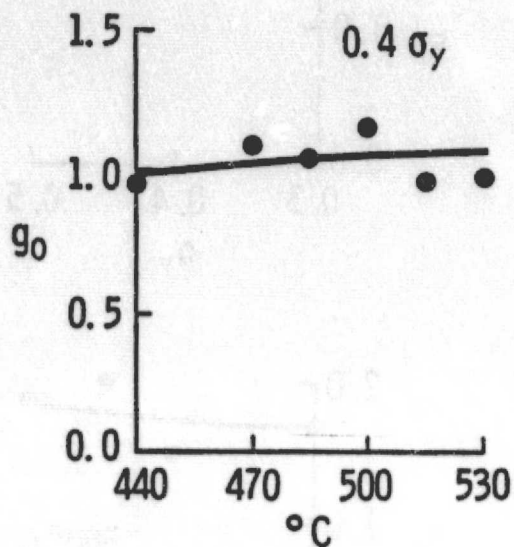


Figure 13. Variation of g_0 with temperature (constant stress) in Ti-6Al-4V.

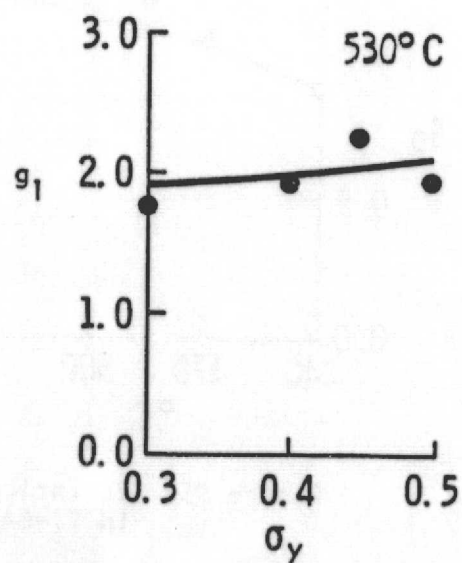
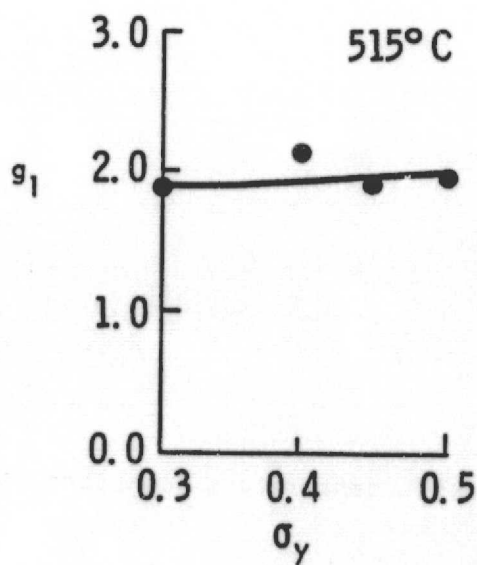
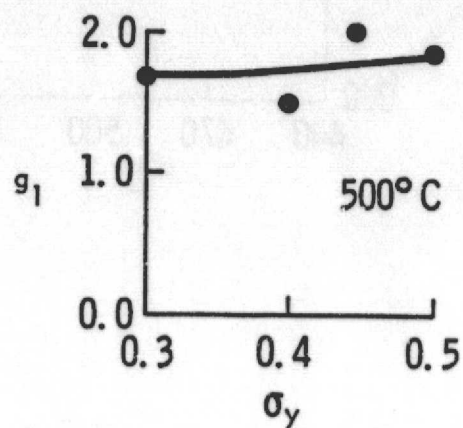
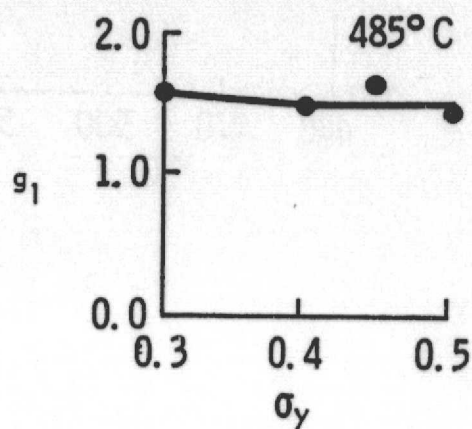
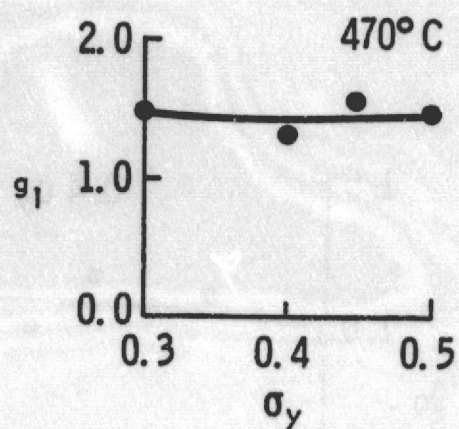
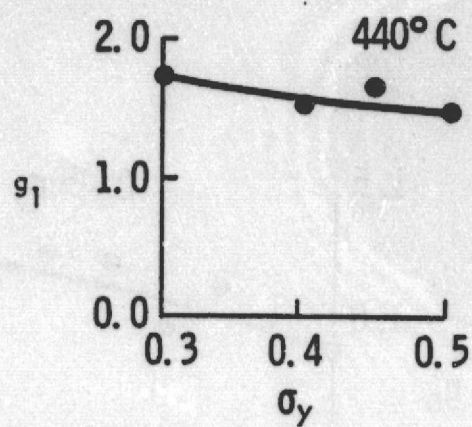


Figure 14. Variation of g_1 with stress (constant temperature) in Ti-6Al-4V.

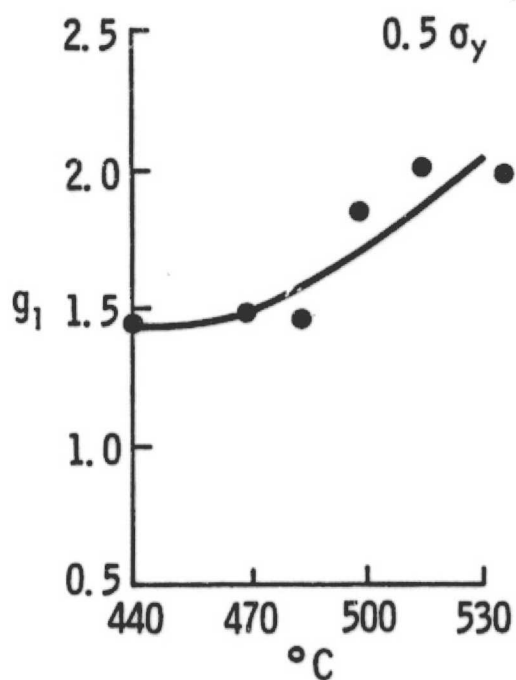
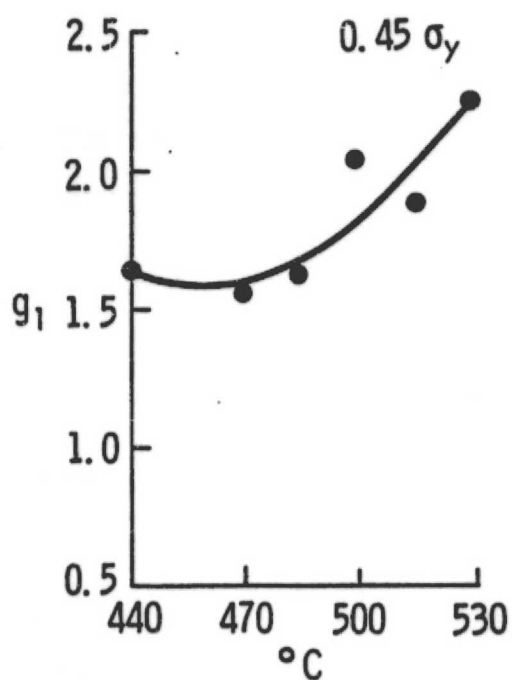
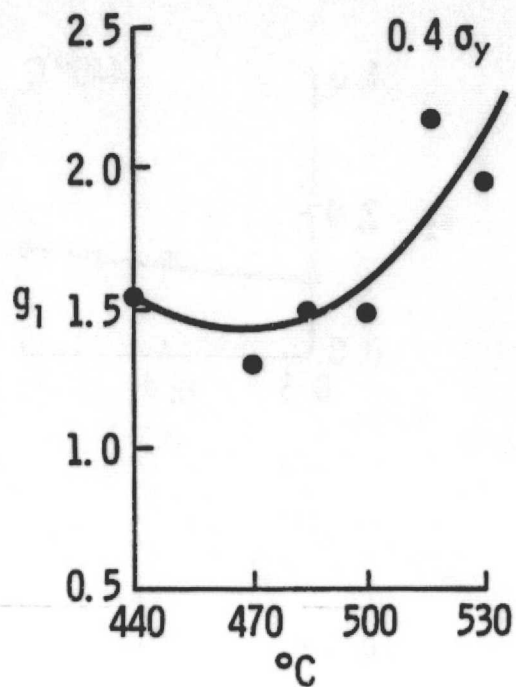
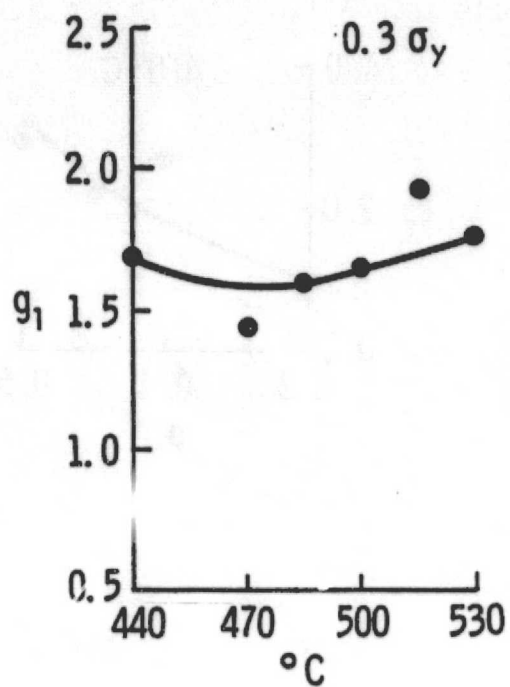


Figure 15. Variation of g_1 with temperature (constant stress) in Ti-6Al-4V.

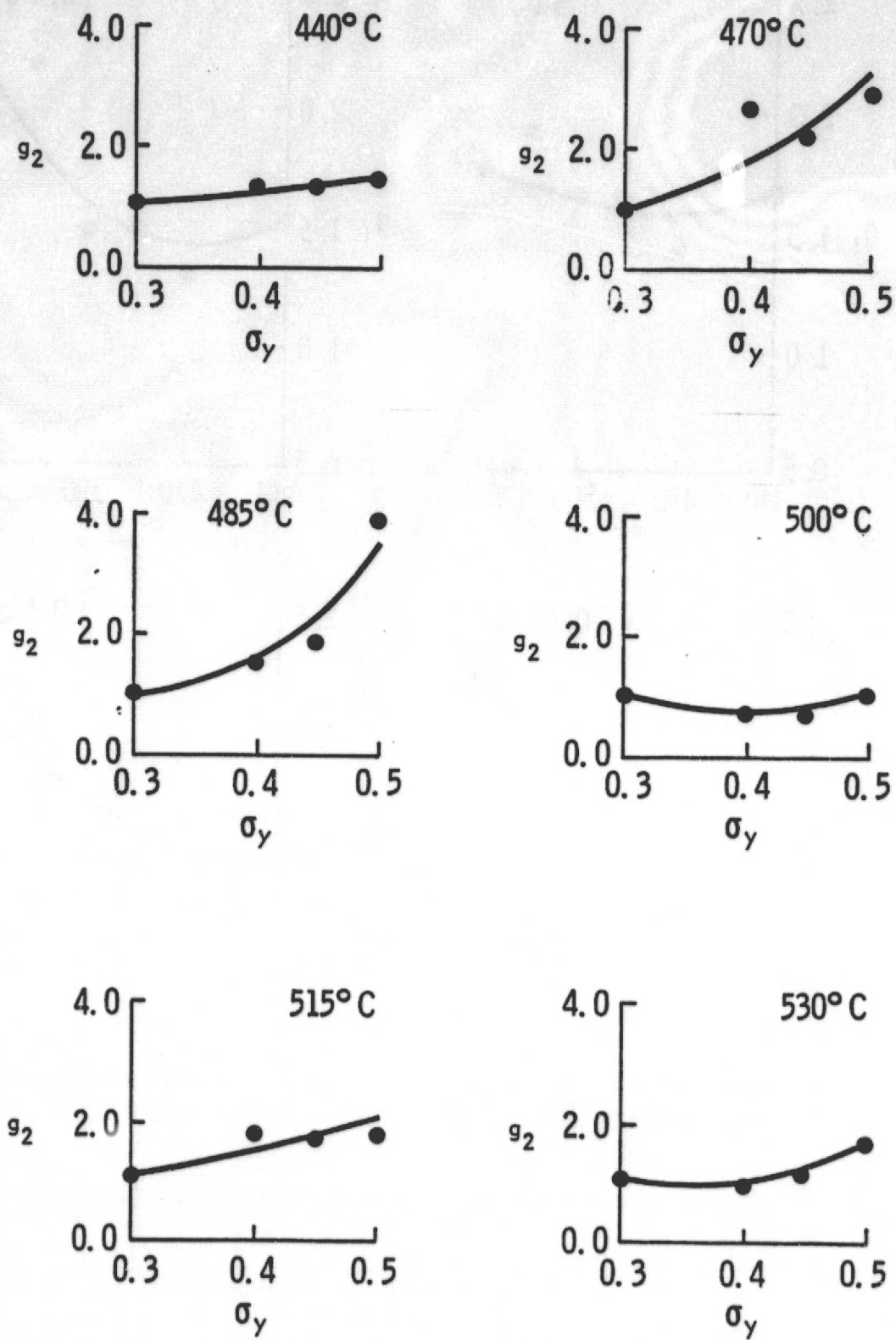


Figure 16. Variation of g_2 with stress (constant temperature) in Ti-6Al-4V.

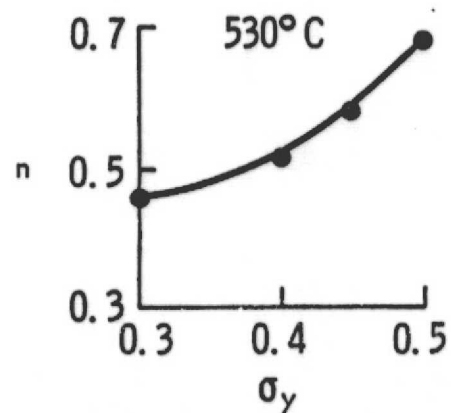
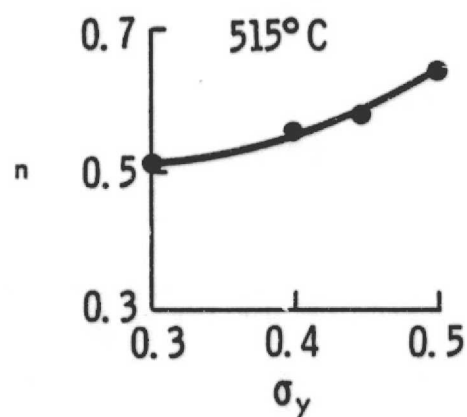
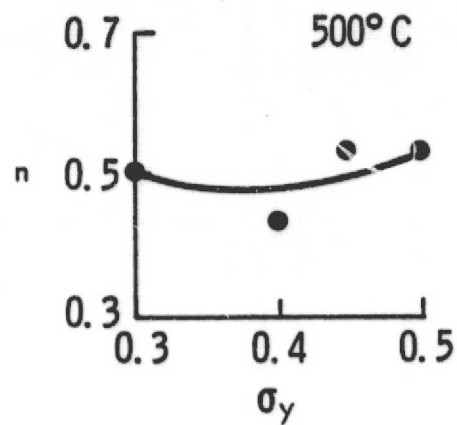
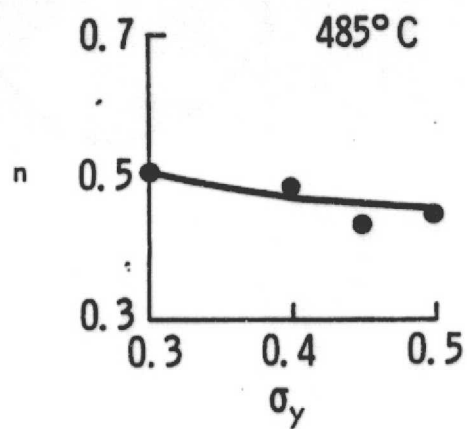
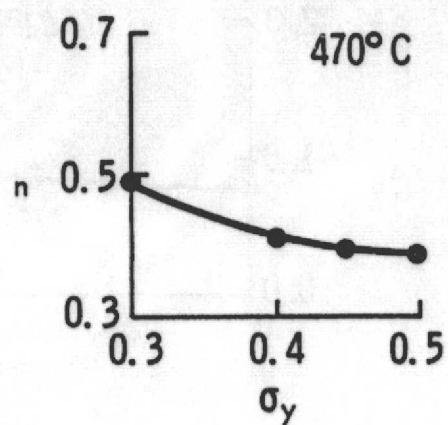
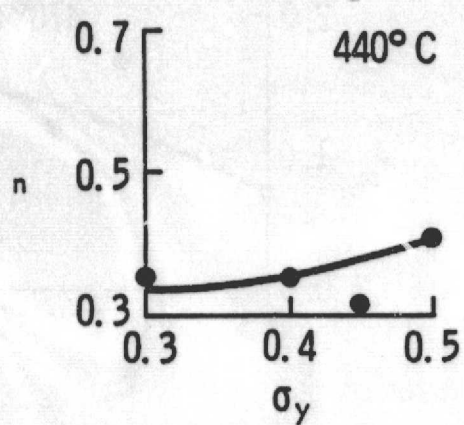


Figure 17. Variation of n with stress (constant temperature) in Ti-6Al-4V.

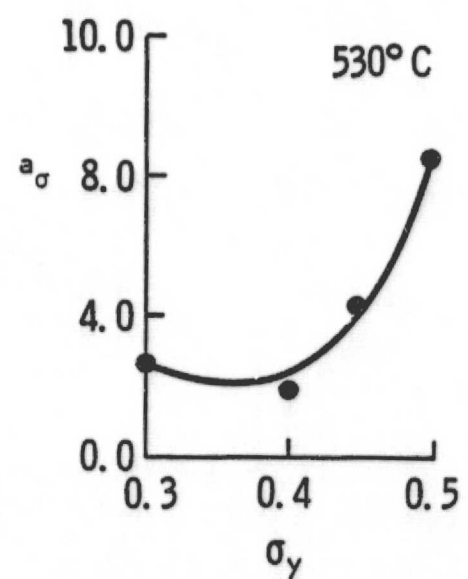
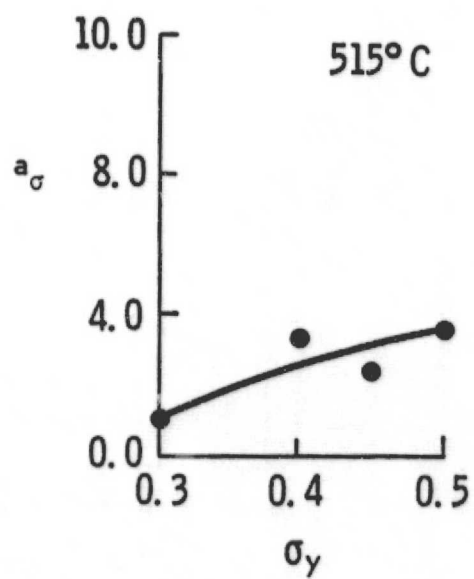
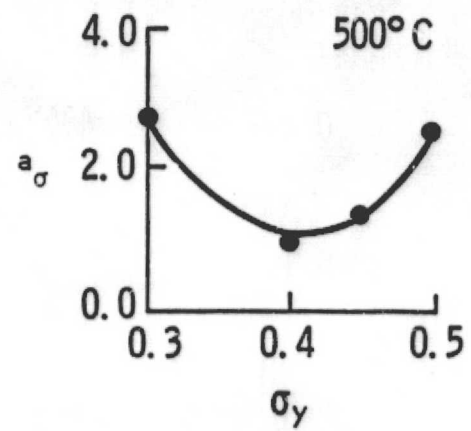
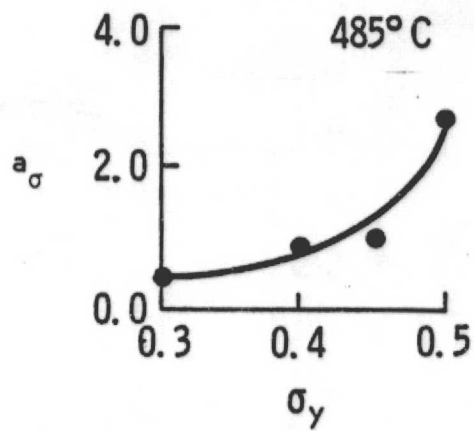
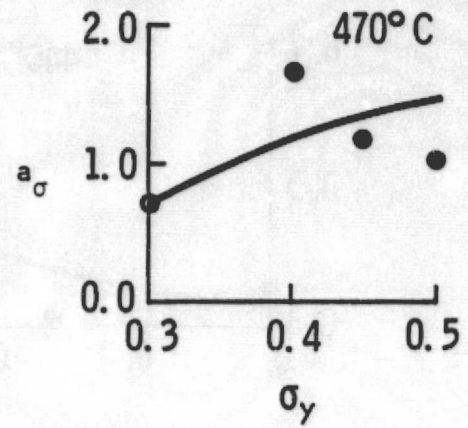
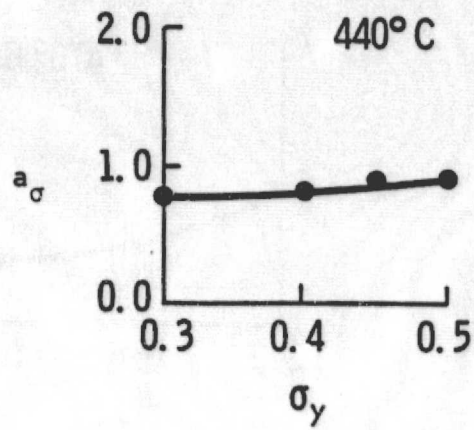


Figure 18. Variation of a_σ with stress (constant temperature) in Ti-6Al-4V.

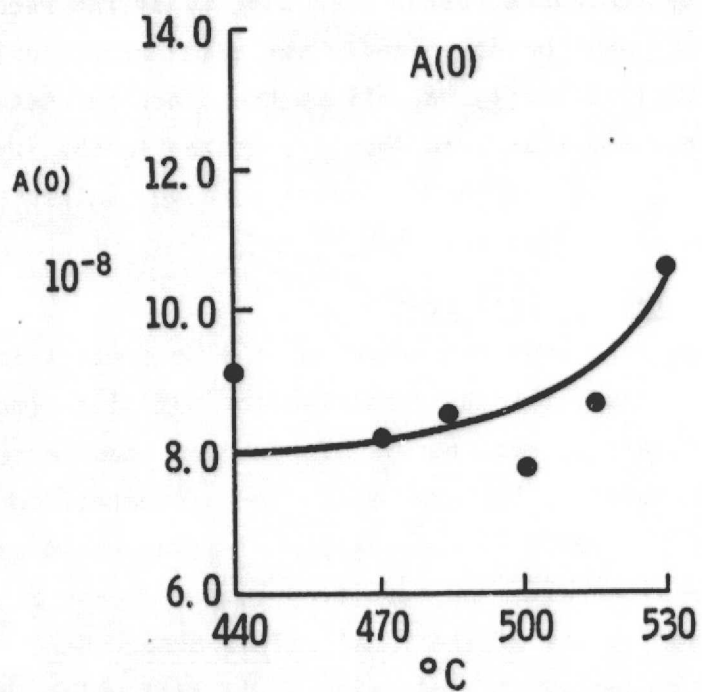
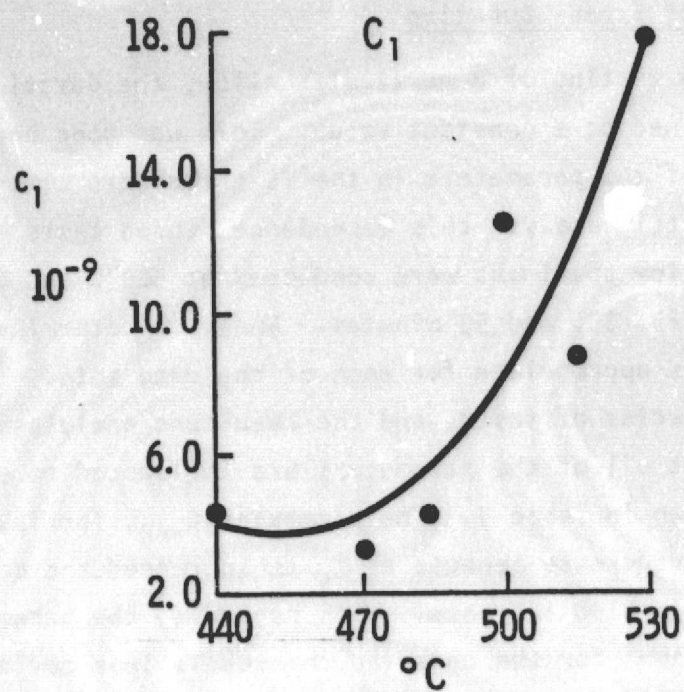


Figure 19. Variation of C_1 and $A(0)$ with temperature in TI-6Al-4V.

Influence of Stress Duration

In the testing of a particular alloy, the duration of stress, t_a , was maintained at a constant value. This was done because it is known that some of the parameters in the TC theory are time-dependent. To more completely analyze this dependence, three tests on three different titanium alloy specimens were conducted at 500°C and $0.4 \sigma_y$. The values of t_a were 19, 39, and 59 minutes. Analyses determined that a value of $n = 0.43$ was appropriate for each of the data sets.

This series of tests, and the resultant analyses of the data, indicated that all of the parameters are influenced to some extent by t_a . This is shown in Table 7. The parameter C_{end} , for instance, would be expected to increase because as t_a is increased the component of plastic strain should also increase. With regard to the parameters g_1 , g_2 and a_σ , the reason for the observed changes is less obvious, but is clearly a reflection of changes in the structure of the material. For example, the parameter g_1 is equal to $[\epsilon(t_a) - \epsilon_0]/C_0$, but the ratio should be maintained relatively constant as $[\epsilon(t_a) - \epsilon_0]$ increases. Apparently this quantity increases faster than does C_0 of the recovery component. The reason for this observation is not clear at present.

The fact that the g_1 as well as the other parameters are time-dependent points out that care should be taken in the experimental design to maintain t_a at a reasonably constant value, unless of course it is the variable to be studied.

Influence of Initial Estimates

The computer-generated values of the parameters in the constitutive equation were thought to be sensitive to initial estimates of some of the experimental values, such as ϵ_0 . To examine these effects, a particular data set was selected for analysis. Three separate computer runs were made involving three different sets of initial estimates. Table 8 gives these values along with the resulting computer-generated final values. Some small variations of the final values among the three runs are observed. Accordingly, the selection of initial values of the parameters does not have a great effect on their final values.

Table 7. Influence of t_a on Parameters

Test	1	2	3
Temperature (C°)	500	500	500
Stress (psi)	26,800	26,800	26,800
t_a (min)	19.25	39.18	59.23
ϵ_0 (10^{-3})	2.352944	2.467316	2.386228
$\epsilon(t_1)$ (10^{-3})	3.5601	4.102876	4.659707
c' (10^{-3})	0.338422	0.337791	0.393095
n	0.43	0.43	0.43
c_6 (10^{-3})	0.889725	1.102441	1.347886
ENT' (a_σ)	1.287772	0.944529	0.717522
c_{end} (10^{-3})	0.526598	0.632071	0.910011
g_0	1.1314	1.1864	1.1474
g_1	1.357	1.484	1.687
g_2	0.8266	0.6603	0.6006

Table 8. Influence of Initial Estimates on Parameters

Test	1		2		3	
	Initial Estamente	Final Value	Initial Estamente	Final Value	Initial Estamente	Final Value
ϵ_0	$2.47 (10^{-3})$	$2.465251 (10^{-3})$	$3.97 (10^{-3})$	$2.556851 (10^{-3})$	$1.97 (10^{-3})$	$2.482009 (10^{-3})$
c'	$0.34 (10^{-3})$	$0.34 (10^{-3})$	$0.90 (10^{-3})$	$0.272490 (10^{-3})$	$0.10 (10^{-3})$	$0.327344 (10^{-3})$
n	0.43	0.428420	0.90	0.474614	0.10	0.436211
n	0.428420	0.428420	0.474614	0.474614	0.436211	0.436211
c_0	$0.93 (10^{-3})$	$1.102945 (10^{-3})$	$0.93 (10^{-3})$	$1.093897 (10^{-3})$	$0.93 (10^{-3})$	$1.1006 (10^{-3})$
ENT (a_0)	1.0	0.938445	1.0	1.133732	1.0	0.968818
c_{end}	$0.80 (10^{-3})$	$0.632531 (10^{-3})$	$0.80 (10^{-3})$	$0.617134 (10^{-3})$	$0.80 (10^{-3})$	$0.630217 (10^{-3})$

DISCUSSION AND CONCLUSIONS

Using the TC theory as a starting point, a generalized constitutive equation that is descriptive of primary creep and relaxation behavior in the titanium alloy Ti-6Al-4V has been developed. In addition, analytical methods have been worked out which enable the use of strain-time data as input for the evaluation the parameters in a TC-based constitutive equation. A further useful result is the "catalogue" of curve forms derived from the parametric study. This allows a quick reference to the influence of a particular parameter on the shape of a creep or relaxation curve, regardless of the material. These curves demonstrate that each parameter has a unique influence.

In the solution of the constitutive equation from data input, one difficulty encountered was fixing the optimum value of the exponent n for the creep and recovery equations. This may indicate that n is a function of stress, or perhaps is strongly influenced by subtle changes in microstructure. This particular example illustrates an aspect that is deserving of further study, which is the influence of microstructure on the parameters of any constitutive equation developed to describe strain-time behavior. Time restrictions prevented any significant exploration of this interesting area, although the subject was addressed in a preliminary way in an earlier study [6]. Obviously, however, alteration of the microstructure through deformation and/or thermal effects must be considered an important component of the whole problem of creep behavior and prediction.

The experimental results demonstrate that the parameters of the generalized constitutive equation are all temperature dependent, the extent depending on the individual parameter. To simplify this complex influence of temperature, a possible method might be based upon an earlier approach by Dorn [9], where the creep rate is expressed as:

$$\dot{\epsilon} = \sum_i Z_i(v, T, S) \sigma_i(T, S) \exp\left[\frac{-\Delta H(T, S)}{RT}\right] \quad (53)$$

where Z is a structural parameter, S is entropy and R is the gas constant. ΔH , the activation energy for creep, is assumed to be independent of σ and ϵ and if entropy is constant

$$\dot{\epsilon} = f(v, T, S)e^{-\Delta H/RT} \quad (54)$$

or

$$\epsilon = \int \dot{\epsilon} dt = \int f(v, T, S)e^{-\Delta H/RT} dt \quad (55)$$

since ΔH is not a function of time

$$\epsilon = e^{-\Delta H/RT} \int f(v, T, S) dt \quad (56)$$

This indicates that strain is a direct function of $e^{-\Delta H/RT}$. In the TC theory this would have its effect on the temperature dependent linear creep compliance, C_1 . Thus the creep and recovery equations could be modified as

$$\epsilon = g_0 C_0 \sigma_0 + G_1 g_2 C_A \left(\frac{t}{a_\sigma}\right)^n \sigma_0 e^{-\Delta H/RT} \quad (57)$$

$$\epsilon_r = \frac{\Delta \epsilon_1}{g_1} e^{-\Delta H/RT} [(1 + a_\sigma \lambda)^n - (a_\sigma \lambda)^n] \quad (58)$$

This approach is probably an oversimplification in that temperature influences do not appear directly in the basic parameters. In some cases, however, it may be a valid approximation.

A conclusion to be drawn from this work is that the TC theory is applicable to the prediction of primary creep and relaxation behavior in metals if the proper form of the constitutive equation can be found for a particular material. In this regard, a disadvantage of the TC theory is its generality. The present study was restricted to the power-law equation form (due to reasons mentioned earlier) with good results, but the constitutive equation needed to be modified with the C_{end} term to more accurately account for plastic deformation. Had time allowed, other modifications to the power-law form may have resulted in constitutive equations that would have been descriptive of events in the other materials studied.

The generality of the TC theory is such that forms other than the power law could have been explored. For instance, incorporating the exponential law, equation (2), into the TC theory,

$$\epsilon = \epsilon_0 + C\sigma_0(1 - e^{-rt}) \quad (59)$$

assuming ϵ_t is a direct function of stress. Using this the TC equation for creep would be

$$\epsilon = g_0 C_0 \sigma_0 + g_1 g_2 C(1 - e^{-r^{t/a_\sigma}}) \sigma_0 \quad (60)$$

and the equation for recovery would be

$$\epsilon_r = g_2 C_0 [(1 - e^{-r(t_a/a_\sigma + t - t_a)}) - (1 - e^{-r(t_a - t_a)})]$$

or

$$\epsilon_r = g_2 C_0 e^{-rt_a} [e^\lambda - e^{(1/a_\sigma + \lambda)}] \quad (61)$$

Accordingly, the exploration of other equation forms, using the TC theory as a basis, may well have shown the theory to be more broadly applicable than was demonstrated in this work.

The apparent disadvantage in trying to use the TC theory as the basis of a predictive method is that large amounts of data are required in order to determine how the parameters will vary as conditions of stress, temperature, and loading time are altered. This is a result of the previously noted generality of the TC theory. In this particular aspect, therefore, the TC theory suffers the same shortcoming as other methods used to predict deformation behavior, i.e., a large data base is a required starting point.

The important large-scale accomplishment of this project is the demonstrated applicability of the TC theory to describing creep and relaxation behavior in metal systems. Modifications were required, as expected, even before significant amounts of data became available because the theory was originally developed for nonmetallic materials. The fact that good results were obtained in an alloy as complex as Ti-6Al-4V is encouraging. This result alone would justify further work.

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EPILOGUE

An aspect of fundamental importance related to the work presented in this report is the educational benefit derived by the several students involved. The grant provided support for two Master of Science students and one Master of Engineering student at the University of Kansas. This final report is a synthesis of the work of these graduate students. In addition, an undergraduate was a part of the project as a laboratory assistant. Accordingly, NSG1269 from NASA/LRC has contributed in a very significant way to the professional development of these students, who all have the potential of making significant contributions to the engineering profession.

APPENDIX A

Parametric Analysis

Program and Results

The parametric analysis, or PLOT, program was written to plot the results of the thermodynamic constitutive theory on the plotter maintained by the University of Kansas Computation Center (UKCC). This program was used to graph the results of the parametric analysis which are located at the end of this appendix. The program has also been used to plot the results of the analysis of test data.

The program calculates the incremental step results from the theory and uses plot routines maintained by the UKCC to write on a computer tape available to the user. This tape is then taken by the user and mounted on the Benson-Lehner incremental plotter which generates the graphs.

Deck Set Up

The deck set up for this program is shown in Figure A1.

The \$ IDENT card must contain a valid project identifier, this project ID must also be approved for use of the plotter. Note that the cost of making one graph similar to those in this appendix is about \$2.50.

The first \$ LIMITS card is required to provide extra memory to compile the mainline program.

The \$ INCODE card designates that the old IBM 026 keypunch was used to write the program. Only an IBM 026 should be used when modifying this program.

The \$ SELECT card is used to access the plot programs maintained by the UKCC.

The \$ TAPE7 card indicates what tape is to be used by the program. The tape # and tape name are the identifiers for the tape assigned by the computer center. The user of this program must have a tape available to the UKCC in order to run this program. For more information on tapes see reference [10].

```

1      8      1
        6

$      IDENT   Project ID number
$      OPTION  FORTRAN
$      FORTRAN NDECK
$      LIMITS  ,29K
$      INCODE  IBMF

main line program
subroutine DATA
$      EXECUTE
$      LIMITS  05, 17K,,1600
$      SELECT  S/STARL
$      TAPE7   08,X3DD,,tape #,, tape name,DEN5
$      INCODE  IBMF    (or IBMEL if 029 used)

data cards
blank card at end of data
$      ENDJOB
***EOF

```

Figure A1. Deck set up for PLOT program

The mainline of the PLOT program is shown in Figure A2. Figure A3 is the DATA subroutine and Figure A4 is the data deck. Figures EXP-1, EXP-2, EXP-3, B-1, B-2, B-3, P-1, P-2, and P-3 at the end of this appendix are the results of this particular program.

A minimum of four data cards are required for each plot. The first 10 spaces in the first card contain the time of the creep curve, the second ten spaces contain the total time (creep + recovery) and the third ten spaces the increment of time to be used in the calculations. The total time divided by the increment of time must be less than 200.

The first 36 spaces of the second data card contain the heading for the output. The first six spaces of this card will also be drawn in the upper right corner of the plot.

The third data card contains, in order, C_0 , C_1 , g_0 , g_1 , g_2 , ENT (or a_0), and EX (or n) using a F10.5 format (ten spaces for each variable). The fourth data card contains, in order, STRS (the stress), B, P, and NLINE using a F10.5, E9.3, F10.5, I4 format. C_0 and C_1 are the elastic and linear creep compliances $\times 10^6$. B and P are user definable variables that are transferred to the subroutine DATA and can be used if special functions of other variables are to be plotted, for example see calculation of ENT in subroutine DATA. NLINE is the interger number of lines to be plotted on that plot.

The mainline program as indicated in Figure A2 is written to plot the equation

$$STRN = C_0 * G_0 * STRS + C_1 * G_1 * G_2 * (T/ENT)**EX * STRS$$

and

$$STRN = G_2 * C_1 * STRS * (T/ENT)**EX * (1 + ENT * TR)**EX - (ENT * TR)**EX$$

If these equations are to be used it should not be necessary to alter the mainline program.

Subroutine DATA is called from the mainline before the values of each line are calculated. It is used to change the initial data values read in on data cards 3 and 4 so as to plot a new line. It is intended that the user will write a small FORTRAN program that will increment a particular parameter value in the data for each curve. This subroutine can also be used to read in completely new values from additional data cards.

```

1      C      CREEP ANALYSIS PROJECT ROSS HOLZLE
2      C      FORMULAS USED BASED ON THERMODYNAMIC CONSTITUTIVE THEORY
3      C      STRN=STRAIN, T(1)=INCREMENTAL TIME, N=NUMBER OF INCREMENTS OF
4      C      CREEP CALCULATIONS, NR=NUMBER OF INCREMENTS OF RECOVERY CALCULATI   ON
5      C      PER=PERIOD-LENGTH OF INCREMENTS OF TIME, STRS=STRESS, CO,C1,GO,
6      C      G1,G2=CONSTANTS, ENT=ENTROPY-LANDA, EX=EXPONENT OF CALCULATION
7      C      B=CONSTANT FOR ENTROPY CALCULATION, U=EXPONENT OF ENTROPY CALC.
8      C      FIRST INPUT DATA CARD SHOULD BE FOR TIME AXIS IN FORM OF
9      C      TIME TO RECOVERY IN HOURS, TOTAL TIME OF TEST, AND INCREMENT OF
10     C      TIME. NEXT DATA CARD CONTAINS TITLE OF GRAPH, THE FIRST SIX
11     C      LETTERS WILL BE REPRODUCED ON THE PLOT. THE NEXT TWO CARDS
12     C      CONTAIN THE VALUES OF THE VARIABLES
13     C
14     C
15     DIMENSION STRN(10,205),T(205),TM(205)
16     DIMENSION XPNT(20)
17     CHARACTER NAME*36
18     DATA T(1),IEXIT,ITAPE,ZERO,NOFF /0.0,0.0,0.0,0.0,-1/
19     DATA XMIN,YMIN/0.0,0.0/
20     DATA ICNT,XD,YD,NDN,NUP/1,10,7,7,2,3/
21     DATA NUP,NDN,NCR,H,THETA,NSIX,NONE,H1/3,2,0.0,2.0,0.6,1.0,15/
22     CALL PLTMFY(IEXIT,ITAPE)
23     DO 78 NPLOT=1,20
24     .17 YMAX=0.0
25     C
26     E      SET-UP TIME ARRAYS
27     C
28     READ(5,13,END=76)TR,TT,PER
29     13 FORMAT(3F10.5)
30     IF(PER.LT.0.00001) GO TO 76
31     N=TR/PER+2
32     NW=TT/PER+3
33     IF(NR.LT.205) GO TO 71
34     WRITE(6,72)
35     72 FORMAT('1','ERROR',/, 'TT/PER IS GREATER THAN 205')
36     GO TO 76
37     71 DO 4 I=2,N
38     4 T(I)=PER*(I-2)
39     DO 5 I=N+1,NR
40     T(I)=PER*(I-3)
41     5 TM(I)=(T(I)-T(N))/T(N)
42     C
43     C      SET UP HEADINGS FOR PAPER OUTPUT
44     C      TR= TIME TO RECOVERY
45     C      TT = TIME TO END OF TEST
46     C      PER = PERIOD, THE LENGTH OF EACH INCREMENT OF TIME
47     C      TT/PER SHOULD BE LESS THAN 200.
48     C
49     READ(5,33) NAME
50     33 FORMAT(A36)
51     WRITE(6,34) NAME
52     34 FORMAT('1',3BX,'PLOT NUMBER',/,26X,A36)

```

Figure A2. Mainline of PLOT program

```

53      WRITE(6,32) T(NH),T(N),PEN                      9
54      32 FORMAT(1X,///,1X,'TIME BASE',/,1X,'TOTAL TIME',F6.1,' HRS',/1X, 8
55      1'RECOVERY AT',F6.1,' HRS',/,1X,'INCREMENT OF TIME',F6.3,' HRS',/, 8
56      2,37X,'INPUT VARIABLES',/)                      8
57      WRITE(6,35)                                       8
58      35 FORMAT(2X,'LINE STRESS CO C1 GO G1 61 ' 7
59      1'G2 EX B P ENT',1X,'NUMBER (PSI)',/)          7
60      C ----- 7
61      C READ IN DATA 7
62      C ----- 6
63      67 READ(5,10,END=16) CO,C1,GO,G1,G2,ENT,EX,STRS,D,P,NLINE 6
64      10 FORMAT(7F10.5,/,F10.4,E 9.3,/,F10.4,14) 6
65      IF(STRS.LT.0.01)GO TO 76
66      CO=CO+.000001 5
67      C1=C1+.000001 5
68      DO 15 NUMH=1,NLINE 5
69      NPLOT=NPLT 5
70      LINE=NUMH 4
71      CALL DATA(CO,C1,GO,G1,G2,ENT,EX,STRS,NPLOT,LINE,D,P) 4
72      C ----- 4
73      C CALCULATIONS 4
74      C ----- 4
75      STRN(NUMH,1)=0.0 3
76      DO 6 I=2,N 3
77      6 STRN(NUMH,I)=(CO+GO*STRS+C1*G1*G2*((T(I)/ENT)**EX)*STRS 3
78      DO 7 I=N+1,NR 2
79      7 STRN(NUMH,I)=G2*C1*STRS*(T(N)/ENT)**EX*((1+ENT*TM(I))**EX- 2
80      1(ENT*TM(I))**EX) 2
81      IF(YMAX.LT.STRN(NUMH,N))YMAX=STRN(NUMH,N) 1
82      IF(YMAX.LT.STRN(NUMH,NR)) YMAX=STRN(NUMH,NR) 1
83      15 CONTINUE U
84      36 XMAX=T(NR) U
85      NPLOT=NPLT U
86      C THIS SECTION CAN BE EXTRACTED AND USED AS A SUBROUTINE TO 40
87      C GENERATE AXIS ON THE KU PLOTTER. TO DO SO EXTRACT ALL CARDS
88      C DOWN THRU '116 CONTINUE'. THE FOLLOWING VALUES SHOULD BE
89      C TRANSFERRED OR DEFINED AT THE BEGINNING OF THE SUBROUTINE--
90      C XMAX AND YMAX=LARGEST X AND Y-V ALUES TO BE PLOTTED
91      C XMIN AND YMIN=MINIMUM X AND Y VALUES TO BE PLOTTED
92      C XD AND YD = X AND Y DIMENSION OF PLOT IN INCHES... ALSO 38
93      C INCLUDE..DIMENSION XPNT(20) 38
94      C DATA NDN,NUP/2,3/ 38
95      C ----- 38
96      XD=10.0
97      YD=7.75
98      ICNT=1
99      A=XMAX 37
100      106 IF(A.GT. 10.0) GO TO 107
101      A=A*10. 37
102      GO TO 106 37
103      107 IF(A.LT. 100.0) GO TO 108
104      A=A*0.1 36

```

Figure A2. Cont'd.

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```

105          GO TO 107
106          108 INT=A+0.8
107          DIVY=0.0
108          DO 200 I=10,20,1
109          200 IF(INT,EQ,1) DIVY=1
110          109 DO 201 I=22,40,2
111          201 IF(INT,EQ,1) DIVY=1/2
112          DO 202 I=45,110,5
113          202 IF(INT,EQ,1) DIVY=1/5
114          IF(DIVY.GT.0.05) GO TO 112
115          INT=INT+1
116          GO TO 109
117          112 IF(ICNT,EQ,2) GO TO 113
118          C
119          C      XPNT AND YPNT ARE THE LOCATIONS OF THE JOGS ON THE AXIS.
120          C      XLEFT AND YAXIS AND MAXIMUM LENGTHS OF THE X AND Y AXIS.
121          C
122          DIVX=DIVY
123          XAXIS=INT*XMAX/A+XMIN
124          ICNT=2
125          A=YMAX
126          GO TO 106
127          113 YDD=YD+1.03
128          YAXIS=INT*YMAX/A+YMIN
129          YLEFT=(YAXIS-YMIN)*1.03+YMIN
130          XDD=XD+1.03
131          XLEFT=(XAXIS-XMIN)*1.03+XMIN
132          CALL INPLOT(XMIN,XLEFT,YMIN,YLEFT,XDD,YDD)
133          CALL PLOT(XMIN,YMIN,NUP,$16)
134          XSTEP=(XAXIS-XMIN)*.02+XMIN
135          YSTEP=(YAXIS-YMIN)*.02+YMIN
136          WRITE(6,117) YAXIS
137          C      PLOT LEFT AXIS
138          DO 115 I=1,DIVY
139          YPNT=(YAXIS-YMIN)*I/DIVY+YMIN
140          Y=YAXIS-YPNT
141          WRITE(6,117) Y
142          117 FORMAT(1X,E10.3,/)
143          CALL PLOT(XMIN,YPNT,NDN,$16)
144          CALL PLOT(XSTEP,YPNT,NDN,$16)
145          115 CALL PLOT(XMIN,YPNT,NDN,$16)
146          CALL PLOT(XMIN,YLEFT,NDN,$16)
147          CALL PLOT(XMIN,YMIN,NUP,$16)
148          C      PLOT BOTTOM AXIS
149          DO 114 I=1,DIVX
150          XPNT(I)=(XAXIS-XMIN)*I/DIVX+XMIN
151          CALL PLOT(XPNT(I),YMIN,NDN,$16)
152          CALL PLOT(XPNT(I),YSTEP,NDN,$16)
153          114 CALL PLOT(XPNT(I),YMIN,NDN,$16)
154          WRITE(6,118) (XPNT(I),I=1,DIVX)
155          118 FORMAT(1X,20F6.1)
156          XSTEP=(XAXIS-XMIN)*1.01+XMIN

```

Figure A2. Cont'd.

```

157      CALL PLOT(XLEFT,YMIN,NDN,$16)                26
158      C      PLOT RIGHT AXIS
159      DO 120 I=1,DIVY                                26
160      YPNT=(YAXIS-YMIN)+I/DIVY*YMIN                26
161      CALL PLOT(XLEFT,YPNT,NDN,$16)                26
162      CALL PLOT(XSTEP,YPNT,NDN,$16)                25
163      120 CALL PLOT(XLEFT,YPNT,NDN,$16)            25
164      CALL PLOT(XLEFT,YLEFT,NDN,$16)
165      YSTEP=(YAXIS-YMIN)+1.01*YMIN
166      CALL PLOT(XMIN,YLEFT,NUP,$16)                25
167      C      PLOT TOP AXIS
168      DO 121 I=1,DIVX                                24
169      CALL PLOT(XPNT(I),YLEFT,NDN,$16)              24
170      CALL PLOT(XPNT(I),YSTEP,NDN,$16)            24
171      121 CALL PLOT(XPNT(I),YLEFT,NDN,$16)          24
172      CALL PLOT(XLEFT,YLEFT,NDN,$16)              23
173      XD =XMAX*XD/XAXIS+XMIN                        23
174      YD =YMAX*YD/YAXIS+YMIN                        23
175      CALL PLOT(XMIN,YMIN,NUP,$16)                  22
176      116 CONTINUE                                  22
177      C
178      C      SUBROUTINE GRAPH DRAWS CURVES ON AXIS-GENERATED BY AXIS. IT
179      C      ALSO INITIALIZES THE PLOTTER PEN FOR THE NEXT PLOT, AFTER
180      C      THREE PLOTS HAVE BEEN MADE THE PEN MUST BE RELOCATED MANUALLY
181      C      ON THE PLOTTER (STOP THE PLOT SEQUENCE, DISENGAGE THE AUTOMATIC
182      C      SWITCH AND MANUALLY RELOCATE THE PEN TO THE BOTTOM OF THE PAPER)
183      C
184      XNAME=XMAX*(1.0-H*NSIX/XD)+XMIN                20
185      YNAME=YMAX*(1.0-H/YD)+YMIN                    20
186      XD=XD+1.1                                      20
187      YD=YD+1.1                                      20
188      XMAX=XMAX+1.1+XMIN                             19
189      YMAX=YMAX+1.1+YMIN                             19
190      CALL INPLOT(XMIN,XMAX,YMIN,YMAX,XD,YD)          19
191      DO 22 LINE=1,NLINE
192      CALL PLOT(XMIN,YMIN,NUP,$77)                  18
193      DO 333 NT=1,NR
194      TIME=T(NT)+XMIN                                18
195      STRN=STRN(LINE,NT)+YMIN                        18
196      333 CALL PLOT(TIME,STRN,NDN,$77)                17
197      LIN=LINE                                         17
198      TIME=T(NR)+1.01+XMIN                           17
199      STRN=STRN(LINE,NR)+YMIN                         17
200      CALL LETTER(TIME,THAN,H1,THETA,NONE,LIN,NCR)   16
201      TIME=T(N)+1.02+YMIN                            16
202      CALL LETTER(TIME,STRN(LINE,N),H1,THETA,NONE,LIN,NCR) 16
203      22 CONTINUE                                    16
204      CALL LETTER(XNAME,YNAME,H,THETA,NSIX,NAME,NSIX) 15
205      CALL PLOT(XMIN,YMAX,NUP,$77)
206      YD=1.5
207      CALL INPLOT(XMIN,XMAX,YMIN,YMAX,XD,YD)          47
208      CALL PLOT(XMIN,YMAX,NUP,$77)                    47
209      78 CONTINUE                                     47
210      16 CONTINUE                                     47
211      76 CALL PLOT(ZERO,ZERO,NUP,$77)                  46
212      77 STOP                                         46
213      END                                             46

```

Figure A2. Cont'd

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1 SUBROUTINE DATA(CO,C1,GO,G1,G2,ENT,EX,STRS,NPLOT,NUMB,J,P)
2 C THIS SUBROUTINE IS USED TO GENERATE THE SUCCESSIVE DATA VARIABLE
3 C FOR EACH PLOT, AFTER THE INITIAL VARIABLES ARE READ IN FROM THE
4 C MAINLINE PROGRAM.
5 C SUBROUTINE IS USED TO ADJUST THE INPUT DATA FOR THE PLOTTER
6 C PROGRAM. CO,C1, GO, G1, G2, ARE CONSTANTS, NOTE THAT CO AND
7 C C1 ARE MULTIPLIED BY 0.000001 IN THE PROGRAM. ENT IS THE
8 C ENTROPY CONSTANT IN THE SCHAPERY EQUATION ($\lambda = \ln A - S/\sigma$).
9 C EX IS THE EXPONENT, STRS IS THE STRESS DURING THE TEST, NPLOT
10 C IS THE CONSECUTIVE NUMBER OF PLOTS DONE TO THAT POINT - 1,2,3
11 C ETC, NUMB IS THE NUMBER OF LINES ON THE PLOT, AND B AND P ARE
12 C EXTRA CONSTANTS WHICH MAY BE USED TO INPUT DATA FOR FUNCTIONS.
13 C THE INPUT DATA TO RUN THE PROGRAM SHOULD FIT THE FOLLOWING
14 C FORMAT.
15 C READ(5,13,END=76) TR,TT,PER
16 C 13 FORMAT(3F10.5)
17 C WHERE TR IS THE TIME TO RECOVERY, TT IS THE TOTAL TIME AND
18 C PER IS THE INCREMENT OF TIME USED IN CALCULATION. TT/PER
19 C SHOULD BE LESS THAN 200.
20 C READ(5,33) NAME
21 C 33 FORMAT(A56)
22 C THE FIRST SIX CHARACTERS OF NAME WILL BE REPRODUCED ON THE
23 C PLOT. THE WHOLE THING WILL BE ON THE PAPER OUTPUT.
24 C 67 READ(5,10,END=16) CO,C1,GO,G1,G2,ENT,EX,STRS,B,P,NLINE
25 C 10 FORMAT(7F10.5,1F10.4,E 9.3,F10.4,14)
26 K=NPLOT
27 GO TO (1,1,1,2,2,2,3,3,3),K
28 1 IF(NUMB.EQ.1) EX=0.2
29 EX=EX+0.1
30 GO TO 13
31 2 IF(NUMB.EQ.1) B=0.1*10.**18.
32 B=B+0.1*10.**18.
33 ENT = B*STRS**P
34 GO TO 13
35 3 IF(NUMB.EQ.1) P=-5.5
36 P=P+.1
37 ENT=B*STRS**P
38 GO TO 13
39 4 CONTINUE
210 STATEMENT IS NEVER REFERENCED
40 5 CONTINUE
41 6 CONTINUE
42 13 CONTINUE
43 11 WRITE(6,12) NUMB,STRS,CO,C1,GO,G1,G2,EX,B,P,ENT
44 12 FORMAT(3X,12,2X,F8.0,2E11.3,3F7.3,3F7.4,2E11.3, F10.5,1)
45 RETURN
46 END

Figure A3. Subroutine DATA for PLOT program

1	1	2	3	3	4	5	6	7
	0	0	0	5	1	1	1	1

	.5	1.0	.005					
--	----	-----	------	--	--	--	--	--

EXP-1 SHORT TIME EXPONENT FUNCTION

	1.6	1.97	1.0		1.0	1.0	1.0	.33333
2500.	0.500E 18	-5.0		9				
10	20	0.1						

EXP-2 MEDIUM EXPONENT FUNCTION

	1.6	1.97	1.0		1.0	1.0	1.0	.33333
2500.	0.500E 18	-5.0		9				
	.	.	.					
	.	.	.					
	.	.	.					
	.	.	.					
10	20	0.1						

P-2 VARIATION OF ENTROPY WITH P

	1.6	1.97	1.0		1.0	1.0	1.0	.33333
2500.	0.500E 18	-5.0		9				
10	110	0.6						

P-3 VARIATION OF ENTROPY WITH P

	1.6	1.97	1.0		1.0	1.0	1.0	.33333
2500.	0.500E 18	-5.0		9				

blank card

Figure A4. Data deck for PLOT program

After the program has finished with a plot, it will start over with a new time information card; if this card is blank or missing the program will stop.

Upon completion of a program run, the computer tape for the plotter may be obtained from the dispatch counter at the computation center. Further information on use and operational details of the plotter is contained in reference [11].

Figure A5 is a short flow chart of the plot program. The program is written such that it solves and plots the equations in increments. Figure A6 is a flow chart for the DATA subroutine.

Explanation of Graphs

The graphs are indexed alphabetically starting with B-1. Using B-1 as an example, the horizontal axis is time and the vertical axis is strain. The first set of curves is for creep and the second for recovery. The line numbers at the end of each line refer to the line number on the following data section. Likewise the B-1 refers to the B-1 in the title of the data section. The title of the data section contains the ID number of the plot and an indication of which parameter was varied. The time base information for the plot is in the upper left corner. The values of the input variables of the equation are indicated below that. Notice that B varies for each line as does ENT since it is a function of B. The figures in the vertical column are the values of the indexes for the vertical axis of the plot. The values on the bottom line are those for the horizontal or time axis of the plot.

In general, each plot is duplicated three times. The first is usually short time with .5 hours for creep and .5 hours for recovery. The second plot is for longer time with ten hours for both creep and recovery. The third plot represents about ten hours creep and 100 hours of recovery.

FLOW CHART
FOR MAINLINE PLOT PROGRAM

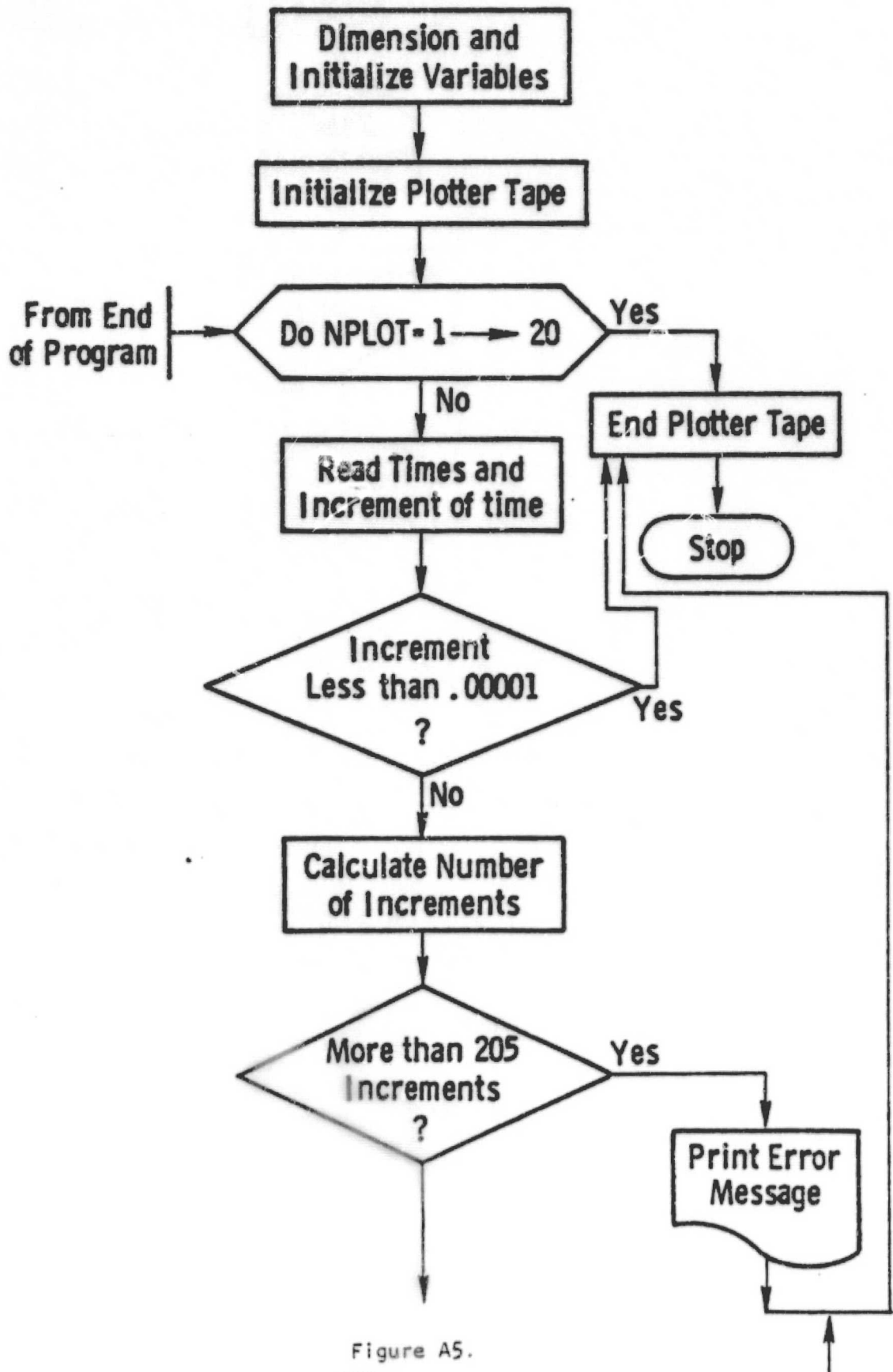


Figure A5.
177

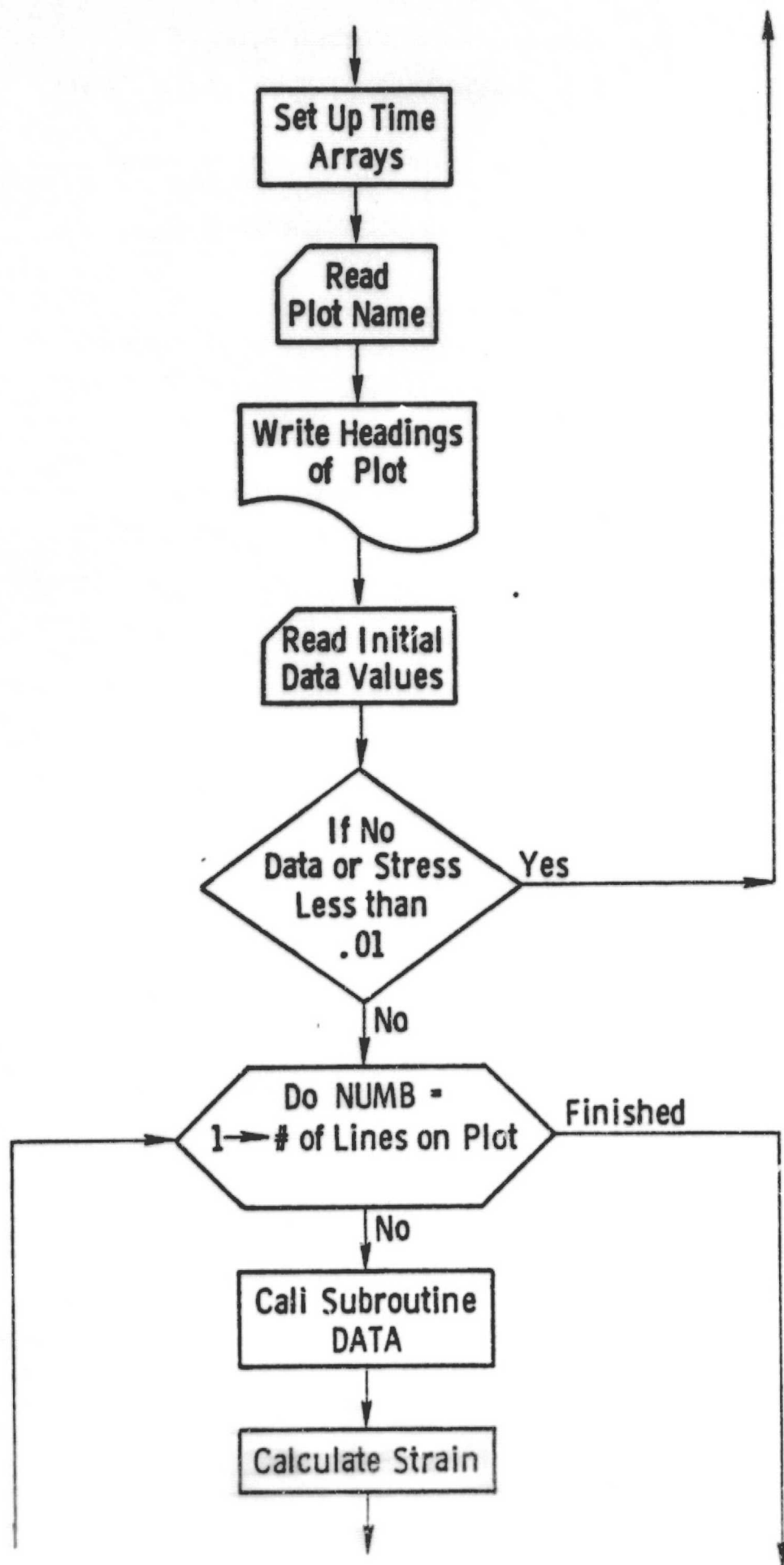


Figure A5. Cont'd.
178

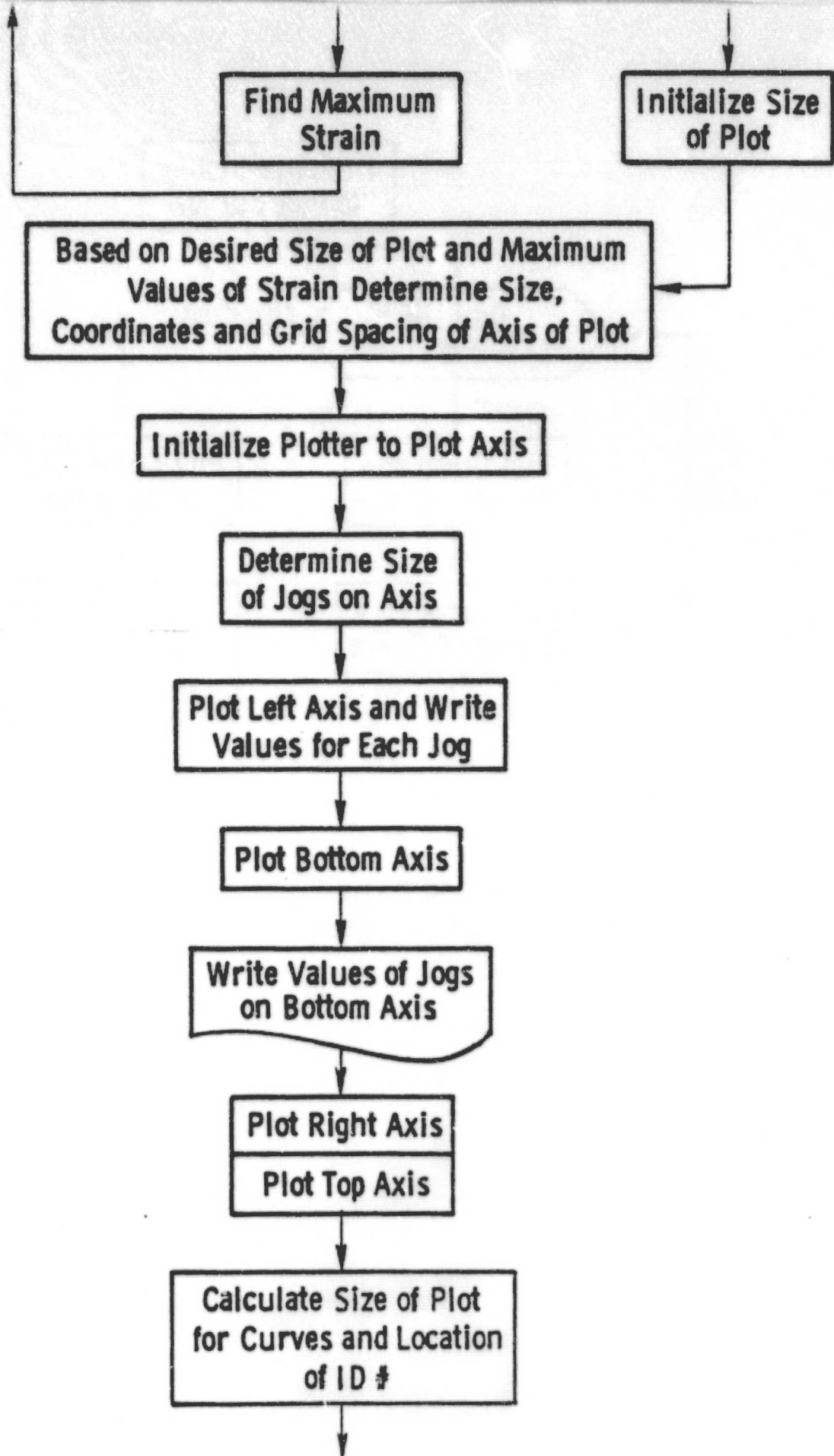


Figure A5. Cont'd.

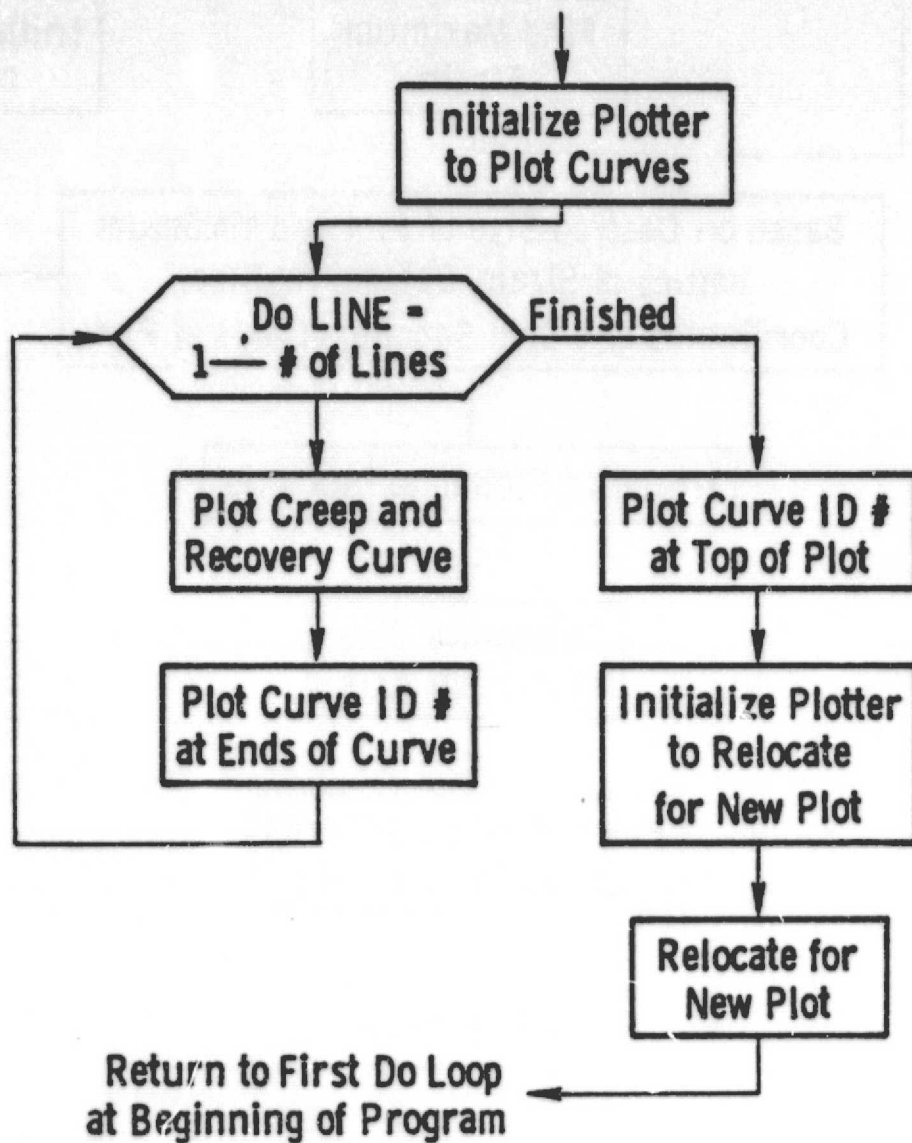


Figure A5. Cont'd.

FLOW CHART FOR SUBROUTINE DATA

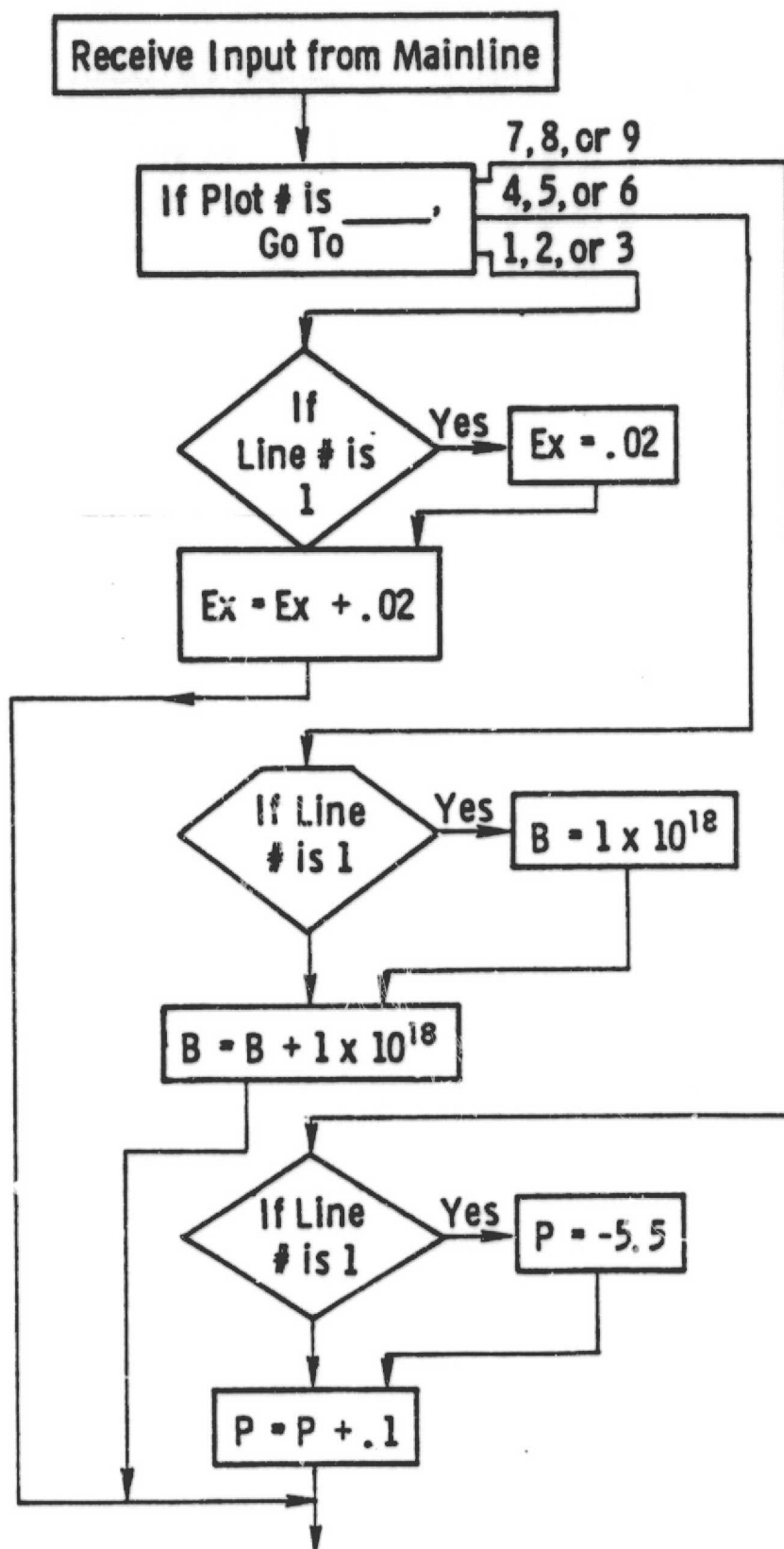
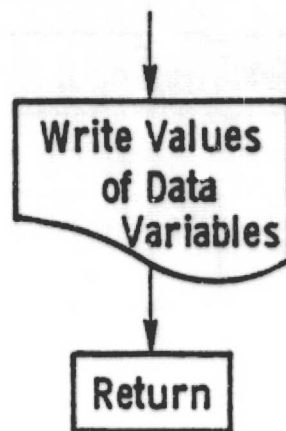
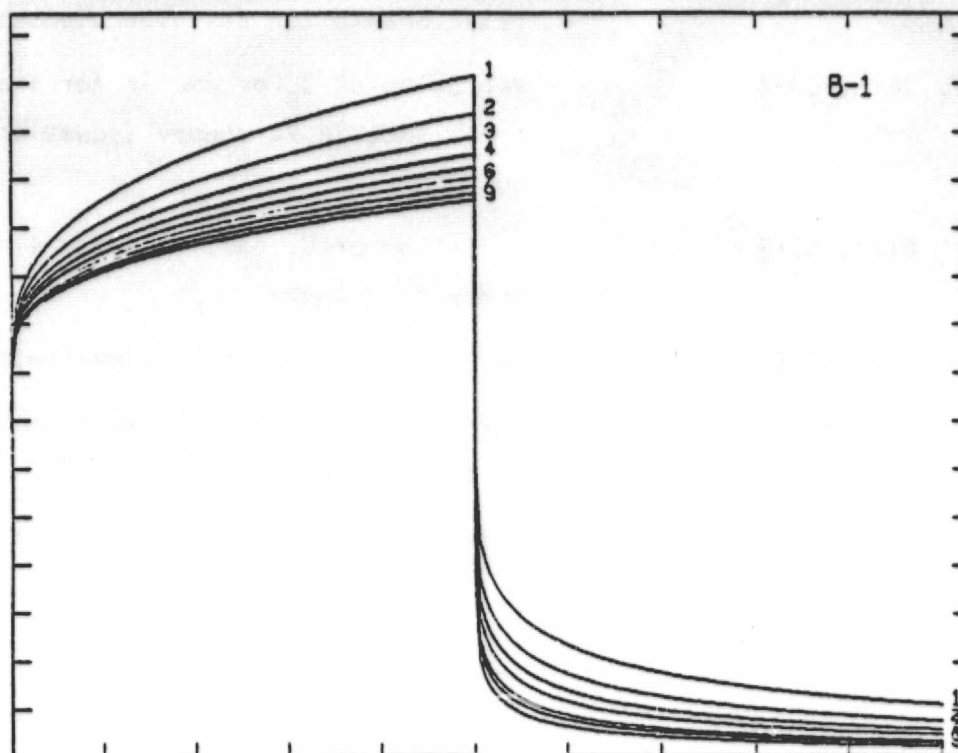


Figure A6.



Index of Plots

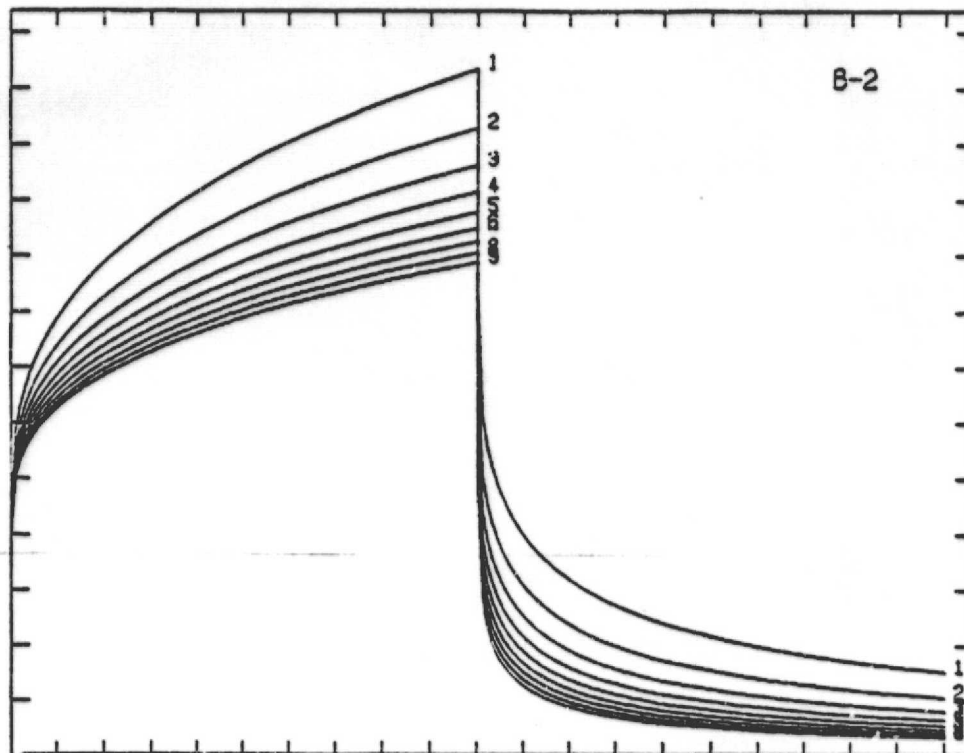
B-1, B-2, B-3	Variation of six parameters in relationship for ENT (see discussion)
CO-1, CO-2, CO-3	Variation of D_0 parameter for elastic compliance in TC theory (equations 36 to 37)
CI-1, CI-2, CI-3	Variation of C_1 parameter for linear creep compliance
ENT-1, ENT-2, ENT-3	Variation of ENT(or a_c) parameter
ENT-1L, ENT-2L, ENT-3L	Large variation of ENT parameter, similar to some results in creep tests
EXP-1, EXP-2, EXP-3	Variation of EX (or n) parameter
G0-1, G0-2, G0-3	Variation of g_0 parameter
G1-1, G1-2, G1-3	Variation of g_1 parameter
G2-1, G2-2, G2-3	Variation of g_2 parameter
P-1, P-2, P-3	Variation of p parameter in relationship for ENT
SIM-1, SIM-2, SIM-3	Simulation of some creep tests by variation of STRS and ENT parameters
STS-1, STS-2, STS-3	Variation of STRS (stress)
STS-1A, STS-2A, STS-3A	Variation of STRS
TEMP-1, TEMP-2, TEMP-3	Variation of TEMP (temperature) using Dorn relationship (see discussion)



PLOT NUMBER
d-1 VARIATION OF d INH+STRS==d

TIME BASE
TOTAL TIME 1.0 HRS
RECOVERY AT 0.5 HRS
INCREMENT OF TIME 0.005 HRS

INPUT VARIABLES										
LINE NUMBER	STRESS (PSI)	C0	C1	C0	G1	G2	EK	A	P	E47
1	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.270E-18	0.500E-01	2.048E0
2	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.370E-18	0.500E-01	3.077E0
3	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.430E-18	0.500E-01	4.046E0
4	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E-18	0.500E-01	5.020E0
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.670E-18	0.500E-01	6.144E0
6	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.750E-18	0.500E-01	7.183E0
7	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.800E-18	0.500E-01	8.133E0
8	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.970E-18	0.500E-01	9.216E0
9	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.120E-19	0.500E-01	10.240E0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	



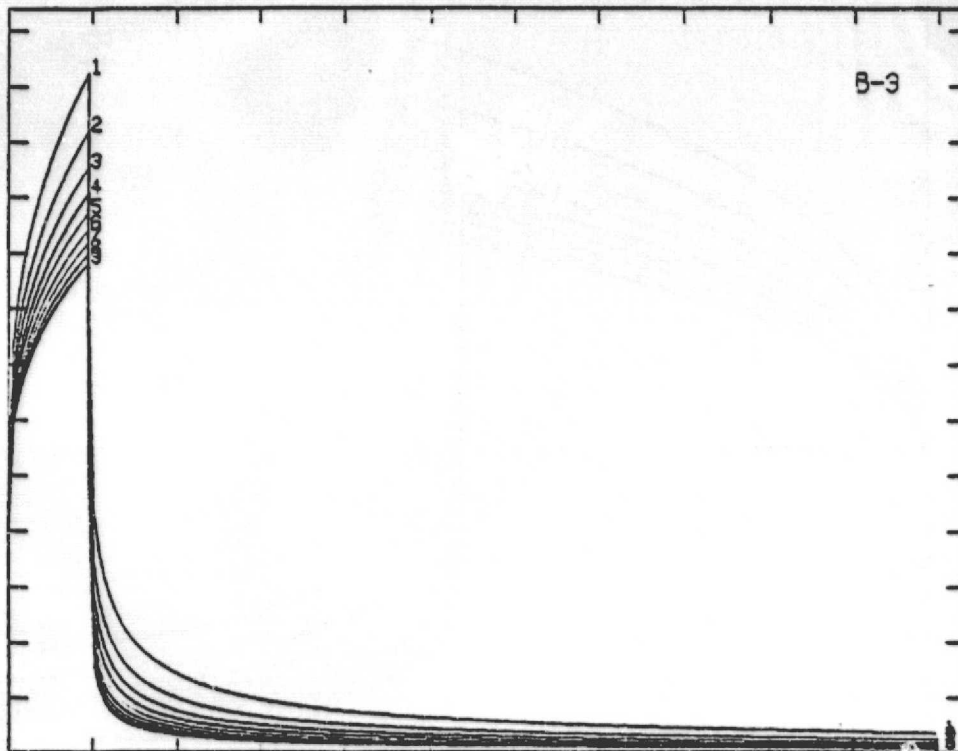
PLOT NUMBER
B-2 VARIATION OF θ IN θ -STRIPES --

```

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 10.0 HRS ---
INCREMENT OF TIME 0.100 HRS

```

[illegible]



PLOT NUMBER
 B-3 VARIATION OF σ IN B-STRESS

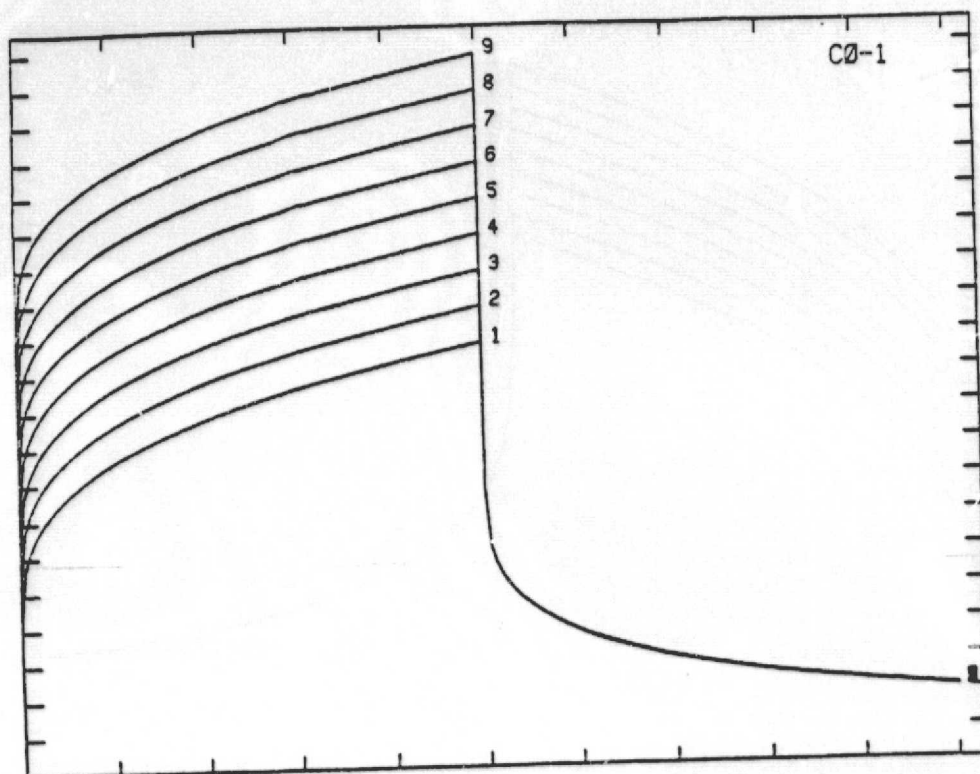
TIME BASE
 TOTAL TIME 120.0 HRS
 RECOVERY AT 0.0 HRS
 INCREMENT OF TIME 0.000 HRS

INPUT VARIABLES

LINE	STRESS	C0	C1	G0	G1	G2	G4	G	P	ENT
NUMBER	(PSI)									
1	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.200E-18	0.500E-01	3.34400
2	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.300E-18	0.500E-01	3.27200
3	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.400E-18	0.500E-01	3.24000
4	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E-18	0.500E-01	3.21000
5	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.600E-18	0.500E-01	3.18000
6	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.700E-18	0.500E-01	3.15000
7	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.800E-18	0.500E-01	3.12000
8	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.900E-18	0.500E-01	3.09000
9	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E-19	0.500E-01	3.06000
0.130E-01										
0.120E-01										
0.110E-01										
0.100E-01										
0.900E-02										
0.800E-02										
0.700E-02										
0.600E-02										
0.500E-02										
0.400E-02										
0.300E-02										
0.200E-02										
0.100E-02										
0										
10.0	25.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0

ORIGINAL PAGE IS
 OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY

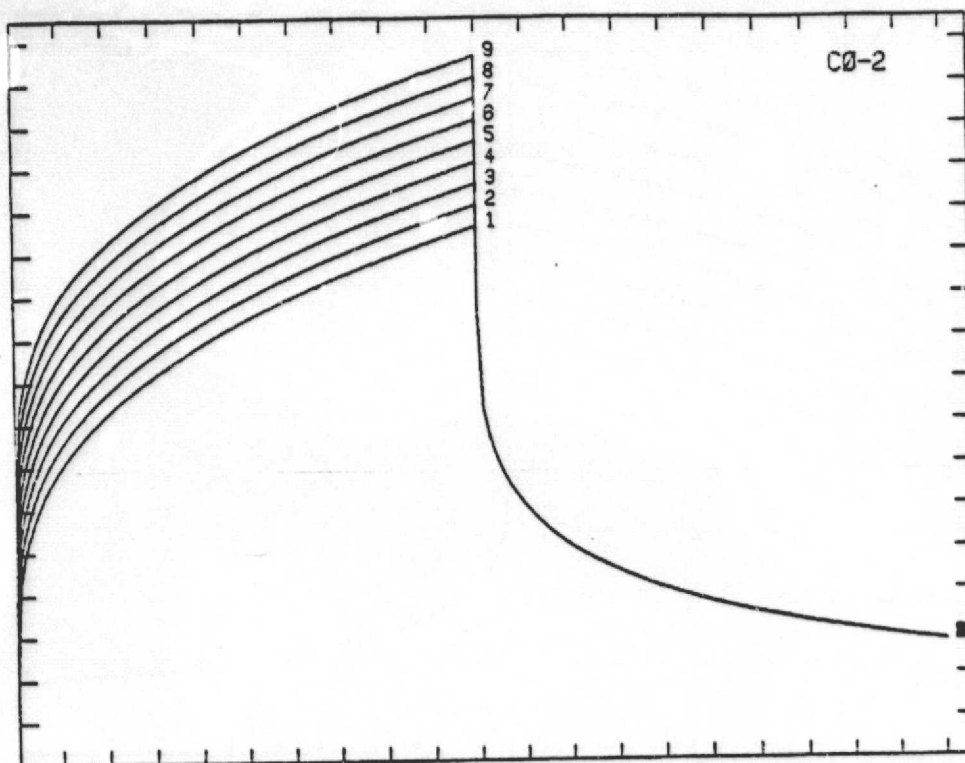


PLOT NUMBER
C0-1 VARIATION OF C0 SHORT TIME

TIME BASE
TOTAL TIME 1.0 HAS
RECOVERY AT 0.3 HAS
INCREMENT OF TIME 0.005 HAS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	EX	S	P	ENT
1	2500	0.100E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
2	2500	0.100E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
3	2500	0.120E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
4	2500	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
5	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
6	2500	0.180E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
7	2500	0.200E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
8	2500	0.220E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
9	2500	0.240E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 21	1.00000
0.100E-01										
0.250E-02										
0.300E-02										
0.350E-02										
0.400E-02										
0.450E-02										
0.500E-02										
0.550E-02										
0.600E-02										
0.650E-02										
0.700E-02										
0.750E-02										
0.800E-02										
0.850E-02										
0.900E-02										
0.950E-02										
1.00E-01										
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	



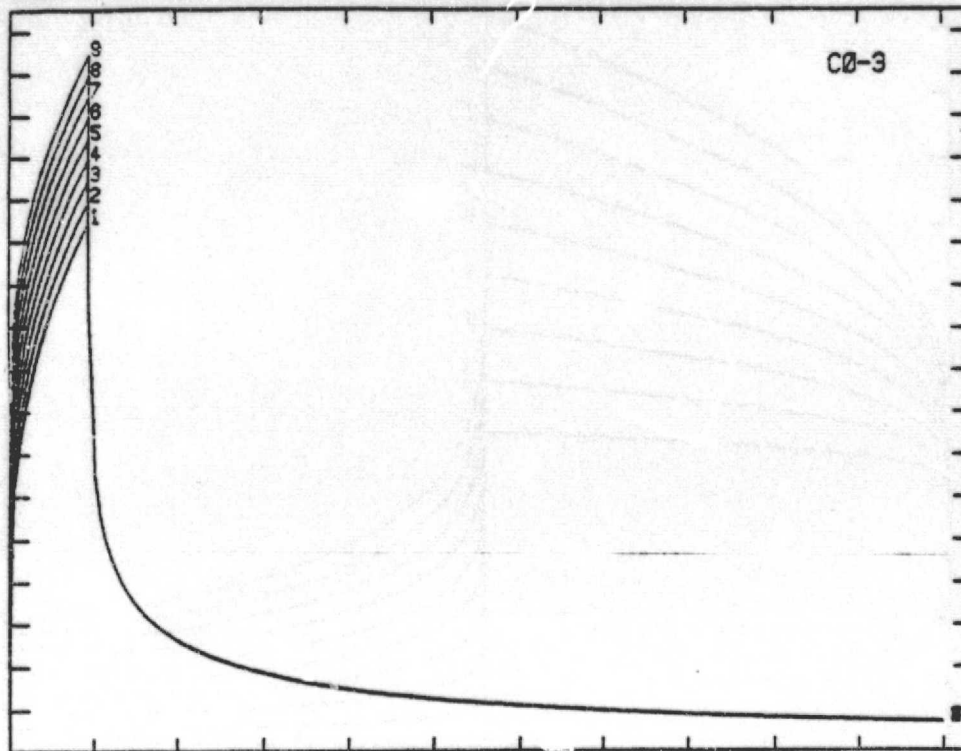
CO-2 VARIATION OF C3 LONG TIME

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 10.0 HRS
INCREMENTS OF TIME 0.100 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
1	2500.	0.800E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
2	2500.	0.100E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
3	2500.	0.120E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
4	2500.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
6	2500.	0.180E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
7	2500.	0.200E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
8	2500.	0.220E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
9	2500.	0.240E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000												
10	0.170E-01																					
11	0.160E-01																					
12	0.150E-01																					
13	0.140E-01																					
14	0.130E-01																					
15	0.120E-01																					
16	0.110E-01																					
17	0.100E-01																					
18	0.900E-02																					
19	0.800E-02																					
20	0.700E-02																					
21	0.600E-02																					
22	0.500E-02																					
23	0.400E-02																					
24	0.300E-02																					
25	0.200E-02																					
26	0.100E-02																					
27	0.																					

C-3

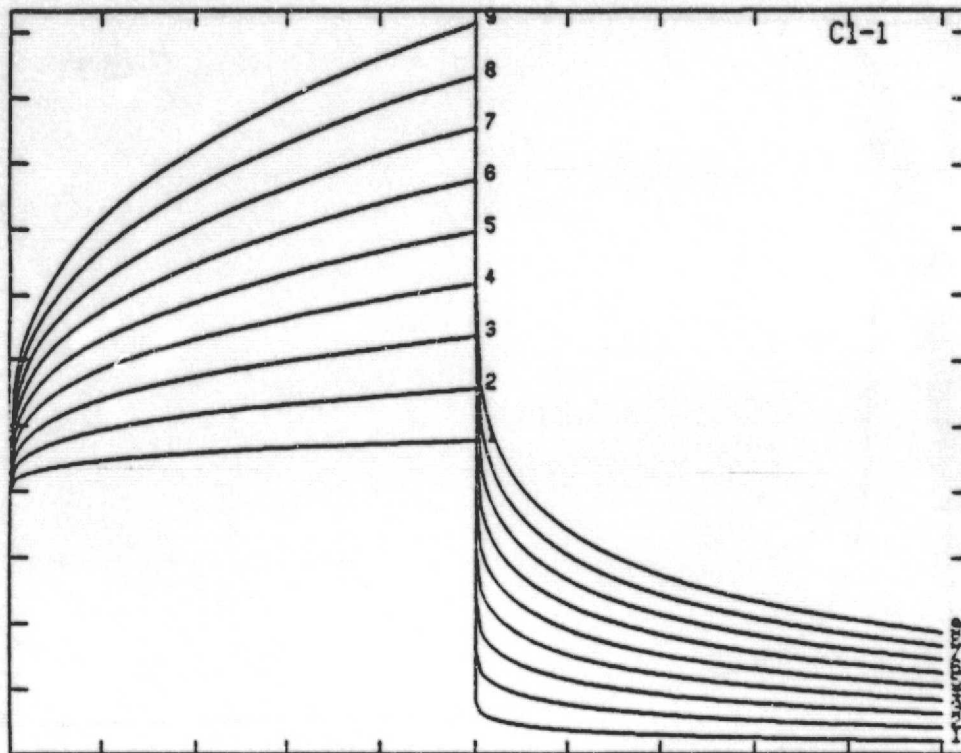
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PLOT NUMBER
CO-3 VARIATION OF CO2 LONG RECOVERY

TIME BASE
TOTAL TIME 109.4 HRS
RECOVERY AT 2.0 HRS
INCREMENT OF TIME 0.000 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	CO	CT	GO	GT	IS2	EA	u	P	ENT
1	2500.	0.807E-06	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
2	2500.	0.100E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
3	2500.	0.120E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
4	2500.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
6	2500.	0.180E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
7	2500.	0.200E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
8	2500.	0.220E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
9	2500.	0.240E-05	0.197E-05	1.000	1.000	1.000	0.5553	0.500E 18	-0.500E 01	1.00000
10	0.170E-01									
11	0.160E-01									
12	0.150E-01									
13	0.140E-01									
14	0.130E-01									
15	0.120E-01									
16	0.110E-01									
17	0.100E-01									
18	0.900E-02									
19	0.800E-02									
20	0.700E-02									
21	0.600E-02									
22	0.500E-02									
23	0.400E-02									
24	0.300E-02									
25	0.200E-02									
26	0.100E-02									
27	0.									
10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0										



PLOT NUMBER
 C1-1 SHORT TIME C1 EFFECT

TIME BASE
 TOTAL TIME 1.0 HRS
 RECOVERY AT 0.5 HRS
 INCREMENT OF TIME 0.005 HRS

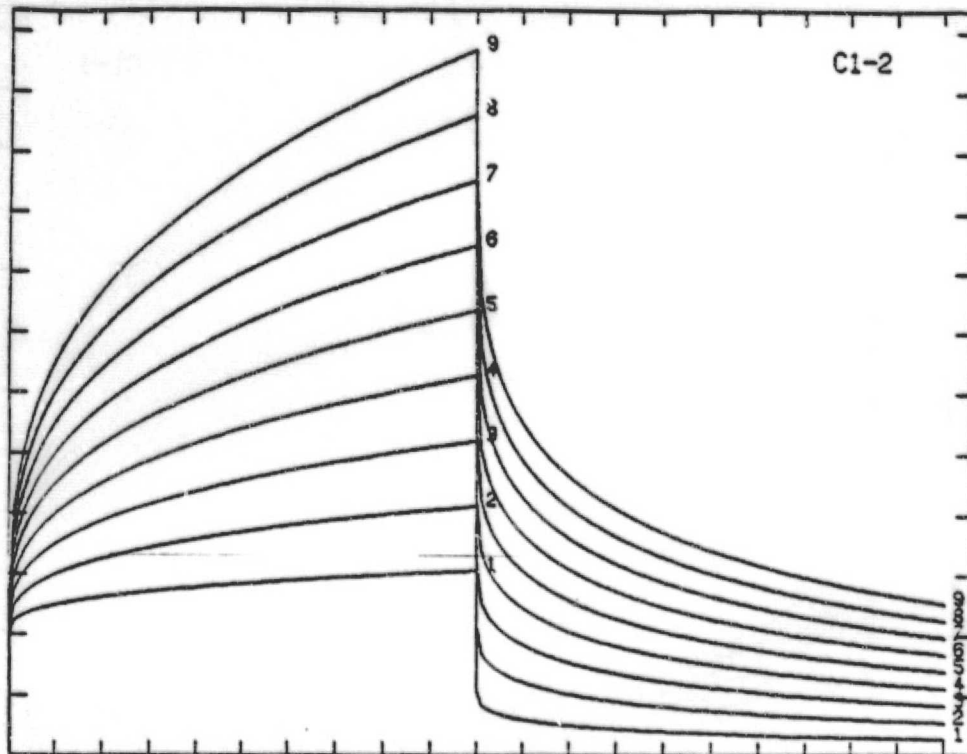
INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	G4	B	P	ENT
1	2500	0.140E-05	0.400E-06	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
2	2500	0.140E-05	0.800E-06	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
3	2500	0.140E-05	0.120E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	2500	0.140E-05	0.160E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
5	2500	0.140E-05	0.200E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
6	2500	0.140E-05	0.240E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
7	2500	0.140E-05	0.280E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
8	2500	0.140E-05	0.320E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	2500	0.140E-05	0.360E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000

0.110E-01
 0.107E-01
 0.900E-02
 0.800E-02
 0.700E-02
 0.600E-02
 0.500E-02
 0.400E-02
 0.300E-02
 0.200E-02
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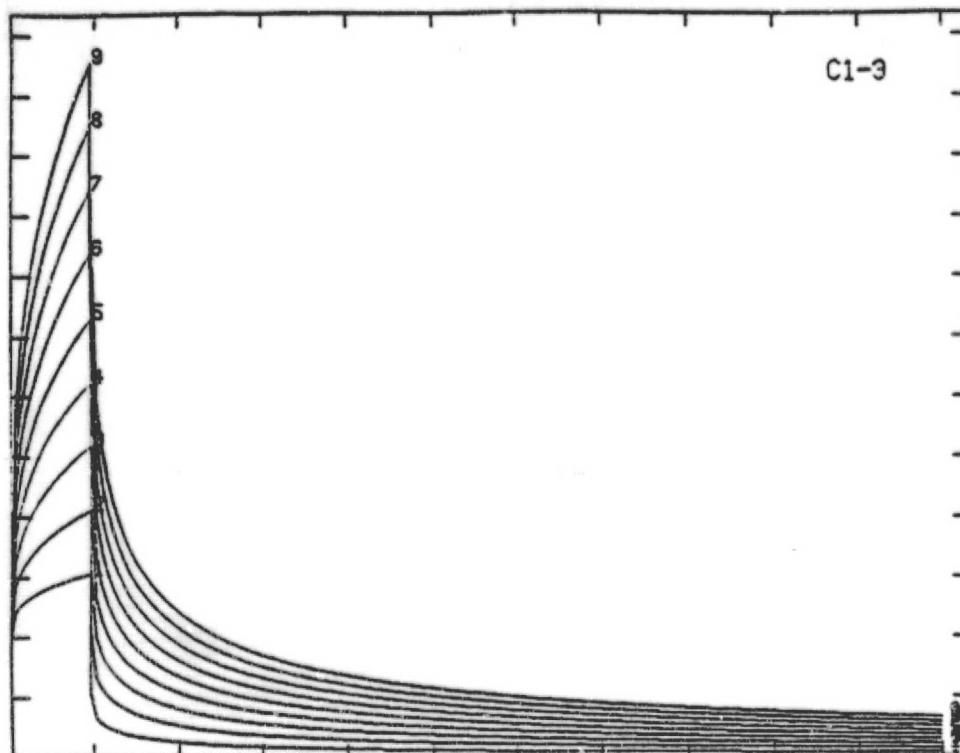


FLAT NUMBER
C1-2 LONG RECOVERY CT EFFECT

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 10.0 HRS
INCREMENT OF TIME 0.100 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	E1	S	P	ENT									
1	2500	0.140E-05	0.400E-06	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
2	2500	0.140E-05	0.800E-06	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
3	2500	0.140E-05	0.120E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
4	2500	0.140E-05	0.140E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
5	2500	0.140E-05	0.200E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
6	2500	0.140E-05	0.240E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
7	2500	0.140E-05	0.280E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
8	2500	0.140E-05	0.320E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
9	2500	0.140E-05	0.360E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000									
0.240E-01																			
0.220E-01																			
0.200E-01																			
0.180E-01																			
0.160E-01																			
0.140E-01																			
0.120E-01																			
0.100E-01																			
0.800E-02																			
0.600E-02																			
0.400E-02																			
0.200E-02																			
0.																			
1.2	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0



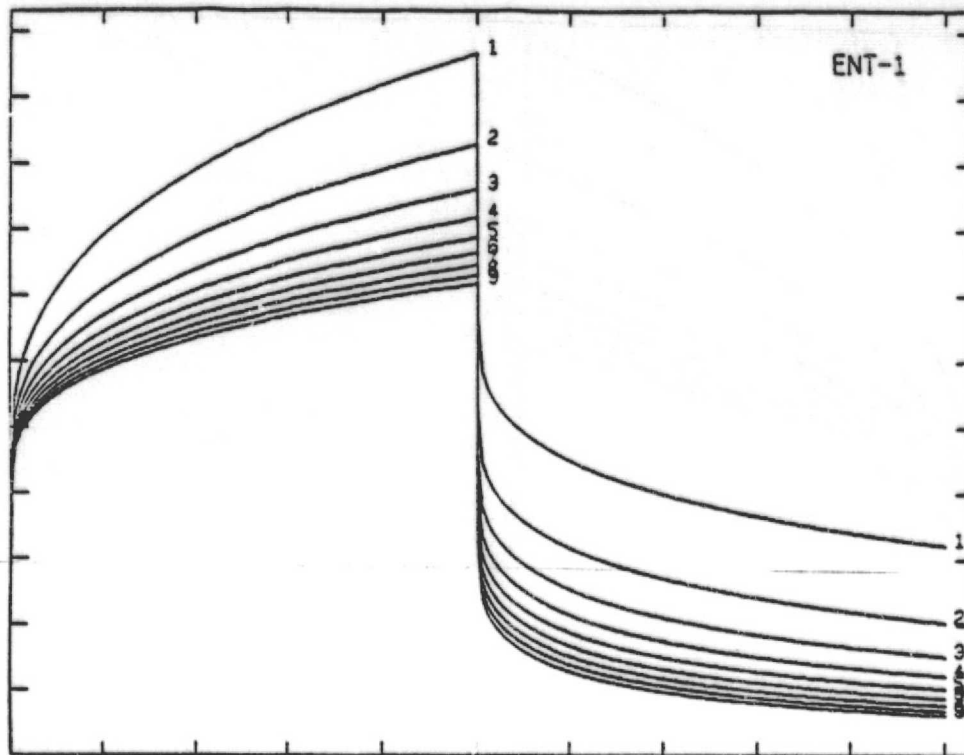
PLOT NUMBER
C1-3 LONG TIME C1 EFFECT

TIME BASE
TOTAL TIME 109.8 HRS
RECOVERY AT 9.8 HRS
INCREMENT OF TIME 0.000 HRS

INPUT VARIABLES

LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C37	C38	C39	C40	C41	C42	C43	C44	C45	C46	C47	C48	C49	C50	C51	C52	C53	C54	C55	C56	C57	C58	C59	C60	C61	C62	C63	C64	C65	C66	C67	C68	C69	C70	C71	C72	C73	C74	C75	C76	C77	C78	C79	C80	C81	C82	C83	C84	C85	C86	C87	C88	C89	C90	C91	C92	C93	C94	C95	C96	C97	C98	C99	C100	C101	C102	C103	C104	C105	C106	C107	C108	C109	C110	C111	C112	C113	C114	C115	C116	C117	C118	C119	C120	C121	C122	C123	C124	C125	C126	C127	C128	C129	C130	C131	C132	C133	C134	C135	C136	C137	C138	C139	C140	C141	C142	C143	C144	C145	C146	C147	C148	C149	C150	C151	C152	C153	C154	C155	C156	C157	C158	C159	C160	C161	C162	C163	C164	C165	C166	C167	C168	C169	C170	C171	C172	C173	C174	C175	C176	C177	C178	C179	C180	C181	C182	C183	C184	C185	C186	C187	C188	C189	C190	C191	C192	C193	C194	C195	C196	C197	C198	C199	C200	C201	C202	C203	C204	C205	C206	C207	C208	C209	C210	C211	C212	C213	C214	C215	C216	C217	C218	C219	C220	C221	C222	C223	C224	C225	C226	C227	C228	C229	C230	C231	C232	C233	C234	C235	C236	C237	C238	C239	C240	C241	C242	C243	C244	C245	C246	C247	C248	C249	C250	C251	C252	C253	C254	C255	C256	C257	C258	C259	C260	C261	C262	C263	C264	C265	C266	C267	C268	C269	C270	C271	C272	C273	C274	C275	C276	C277	C278	C279	C280	C281	C282	C283	C284	C285	C286	C287	C288	C289	C290	C291	C292	C293	C294	C295	C296	C297	C298	C299	C300	C301	C302	C303	C304	C305	C306	C307	C308	C309	C310	C311	C312	C313	C314	C315	C316	C317	C318	C319	C320	C321	C322	C323	C324	C325	C326	C327	C328	C329	C330	C331	C332	C333	C334	C335	C336	C337	C338	C339	C340	C341	C342	C343	C344	C345	C346	C347	C348	C349	C350	C351	C352	C353	C354	C355	C356	C357	C358	C359	C360	C361	C362	C363	C364	C365	C366	C367	C368	C369	C370	C371	C372	C373	C374	C375	C376	C377	C378	C379	C380	C381	C382	C383	C384	C385	C386	C387	C388	C389	C390	C391	C392	C393	C394	C395	C396	C397	C398	C399	C400	C401	C402	C403	C404	C405	C406	C407	C408	C409	C410	C411	C412	C413	C414	C415	C416	C417	C418	C419	C420	C421	C422	C423	C424	C425	C426	C427	C428	C429	C430	C431	C432	C433	C434	C435	C436	C437	C438	C439	C440	C441	C442	C443	C444	C445	C446	C447	C448	C449	C450	C451	C452	C453	C454	C455	C456	C457	C458	C459	C460	C461	C462	C463	C464	C465	C466	C467	C468	C469	C470	C471	C472	C473	C474	C475	C476	C477	C478	C479	C480	C481	C482	C483	C484	C485	C486	C487	C488	C489	C490	C491	C492	C493	C494	C495	C496	C497	C498	C499	C500	C501	C502	C503	C504	C505	C506	C507	C508	C509	C510	C511	C512	C513	C514	C515	C516	C517	C518	C519	C520	C521	C522	C523	C524	C525	C526	C527	C528	C529	C530	C531	C532	C533	C534	C535	C536	C537	C538	C539	C540	C541	C542	C543	C544	C545	C546	C547	C548	C549	C550	C551	C552	C553	C554	C555	C556	C557	C558	C559	C560	C561	C562	C563	C564	C565	C566	C567	C568	C569	C570	C571	C572	C573	C574	C575	C576	C577	C578	C579	C580	C581	C582	C583	C584	C585	C586	C587	C588	C589	C590	C591	C592	C593	C594	C595	C596	C597	C598	C599	C600	C601	C602	C603	C604	C605	C606	C607	C608	C609	C610	C611	C612	C613	C614	C615	C616	C617	C618	C619	C620	C621	C622	C623	C624	C625	C626	C627	C628	C629	C630	C631	C632	C633	C634	C635	C636	C637	C638	C639	C640	C641	C642	C643	C644	C645	C646	C647	C648	C649	C650	C651	C652	C653	C654	C655	C656	C657	C658	C659	C660	C661	C662	C663	C664	C665	C666	C667	C668	C669	C670	C671	C672	C673	C674	C675	C676	C677	C678	C679	C680	C681	C682	C683	C684	C685	C686	C687	C688	C689	C690	C691	C692	C693	C694	C695	C696	C697	C698	C699	C700	C701	C702	C703	C704	C705	C706	C707	C708	C709	C710	C711	C712	C713	C714	C715	C716	C717	C718	C719	C720	C721	C722	C723	C724	C725	C726	C727	C728	C729	C730	C731	C732	C733	C734	C735	C736	C737	C738	C739	C740	C741	C742	C743	C744	C745	C746	C747	C748	C749	C750	C751	C752	C753	C754	C755	C756	C757	C758	C759	C760	C761	C762	C763	C764	C765	C766	C767	C768	C769	C770	C771	C772	C773	C774	C775	C776	C777	C778	C779	C780	C781	C782	C783	C784	C785	C786	C787	C788	C789	C790	C791	C792	C793	C794	C795	C796	C797	C798	C799	C800	C801	C802	C803	C804	C805	C806	C807	C808	C809	C810	C811	C812	C813	C814	C815	C816	C817	C818	C819	C820	C821	C822	C823	C824	C825	C826	C827	C828	C829	C830	C831	C832	C833	C834	C835	C836	C837	C838	C839	C840	C841	C842	C843	C844	C845	C846	C847	C848	C849	C850	C851	C852	C853	C854	C855	C856	C857	C858	C859	C860	C861	C862	C863	C864	C865	C866	C867	C868	C869	C870	C871	C872	C873	C874	C875	C876	C877	C878	C879	C880	C881	C882	C883	C884	C885	C886	C887	C888	C889	C890	C891	C892	C893	C894	C895	C896	C897	C898	C899	C900	C901	C902	C903	C904	C905	C906	C907	C908	C909	C910	C911	C912	C913	C914	C915	C916	C917	C918	C919	C920	C921	C922	C923	C924	C925	C926	C927	C928	C929	C930	C931	C932	C933	C934	C935	C936	C937	C938	C939	C940	C941	C942	C943	C944	C945	C946	C947	C948	C949	C950	C951	C952	C953	C954	C955	C956	C957	C958	C959	C960	C961	C962	C963	C964	C965	C966	C967	C968	C969	C970	C971	C972	C973	C974	C975	C976	C977	C978	C979	C980	C981	C982	C983	C984	C985	C986	C987	C988	C989	C990	C991	C992	C993	C994	C995	C996	C997	C998	C999	C1000	C1001	C1002	C1003	C1004	C1005	C1006	C1007	C1008	C1009	C1010	C1011	C1012	C1013	C1014	C1015	C1016	C1017	C1018	C1019	C1020	C1021	C1022	C1023	C1024	C1025	C1026	C1027	C1028	C1029	C1030	C1031	C1032	C1033	C1034	C1035	C1036	C1037	C1038	C1039	C1040	C1041	C1042	C1043	C1044	C1045	C1046	C1047	C1048	C1049	C1050	C1051	C1052	C1053	C1054	C1055	C1056	C1057	C1058	C1059	C1060	C1061	C1062	C1063	C1064	C1065	C1066	C1067	C1068	C1069	C1070	C1071	C1072	C1073	C1074	C1075	C1076	C1077	C1078	C1079	C1080	C1081	C1082	C1083	C1084	C1085	C1086	C1087	C1088	C1089	C1090	C1091	C1092	C1093	C1094	C1095	C1096	C1097	C1098	C1099	C1100	C1101	C1102	C1103	C1104	C1105	C1106	C1107	C1108	C1109	C1110	C1111	C1112	C1113	C1114	C1115	C1116	C1117	C1118	C1119	C1120	C1121	C1122	C1123	C1124	C1125	C1126	C1127	C1128	C1129	C1130	C1131	C1132	C1133	C1134	C1135	C1136	C1137	C1138	C1139	C1140	C1141	C1142	C1143	C1144	C1145	C1146	C1147	C1148	C1149	C1150	C1151	C1152	C1153	C1154	C1155	C1156	C1157	C1158	C1159	C1160	C1161	C1162	C1163	C1164	C1165	C1166	C1167	C1168	C1169	C1170	C1171	C1172	C1173	C1174	C1175	C1176	C1177	C1178	C1179	C1180	C1181	C1182	C1183	C1184	C1185	C1186	C1187	C1188	C1189	C1190	C1191	C1192	C1193	C1194	C1195	C1196	C1197	C1198	C1199	C1200	C1201	C1202	C1203	C1204	C1205	C1206	C1207	C1208	C1209	C1210	C1211	C1212	C1213	C1214	C1215	C1216	C1217	C1218	C1219	C1220	C1221	C1222	C1223	C1224	C1225	C1226	C1227	C1228	C1229	C1230	C1231	C1232	C1233	C1234	C1235	C1236	C1237	C1238	C1239	C1240	C1241	C1242	C1243	C1244	C1245	C1246	C1247	C1248	C1249	C1250	C1251	C1252	C1253	C1254	C1255	C1256	C1257	C1258	C1259	C1260	C1261	C1262	C1263	C1264	C1265	C1266	C1267	C1268	C1269	C1270	C1271	C1272	C1273	C1274	C1275	C1276	C1277	C1278	C1279	C1280	C1281	C1282	C1283	C1284	C1285	C1286	C1287	C1288	C1289	C1290	C1291	C1292	C1293	C1294	C1295	C1296	C1297	C1298	C1299	C1300	C1301	C1302	C1303	C1304	C1305	C1306	C1307	C1308	C1309	C1310	C1311	C1312	C1313	C1314	C1315	C1316	C1317	C1318	C1319	C1320	C1321	C1322	C1323	C1324	C1325	C1326	C1327	C1328	C1329	C1330	C1331	C1332	C1333	C1334	C1335	C1336	C1337	C1338	C1339	C1340	C1341	C1342	C1343	C1344	C1345	C1346	C1347	C1348	C1349	C1350	C1351	C1352	C1353	C1354	C1355	C1356	C1357	C1358	C1359	C1360	C1361	C1362	C1363	C1364	C1365	C1366	C1367	C1368	C1369	C1370	C1371	C1372	C1373	C1374	C1375	C1376	C1377	C1378	C1379	C1380	C1381	C1382	C1383	C1384	C1385	C1386	C1387	C1388	C1389	C1390	C1391	C1392	C1393	C1394	C1395	C1396	C1397	C1398	C1399	C1400	C1401	C1402	C1403	C1404	C1405	C1406	C1407	C1408	C1409	C1410	C1411	C1412	C1413	C1414	C1415	C1416	C1417	C1418	C1419	C1420	C1421	C1422	C1423	C1424	C1425	C1426	C1427	C1428	C1429	C1430	C1431	C1432	C1433	C1434	C1435	C1436	C1437	C1438	C1439	C1440	C1441	C1442	C1443	C1444	C1445	C1446	C1447	C1448	C1449	C1450	C1451	C1452	C1453	C1454	C1455	C1456	C1457	C1458	C1
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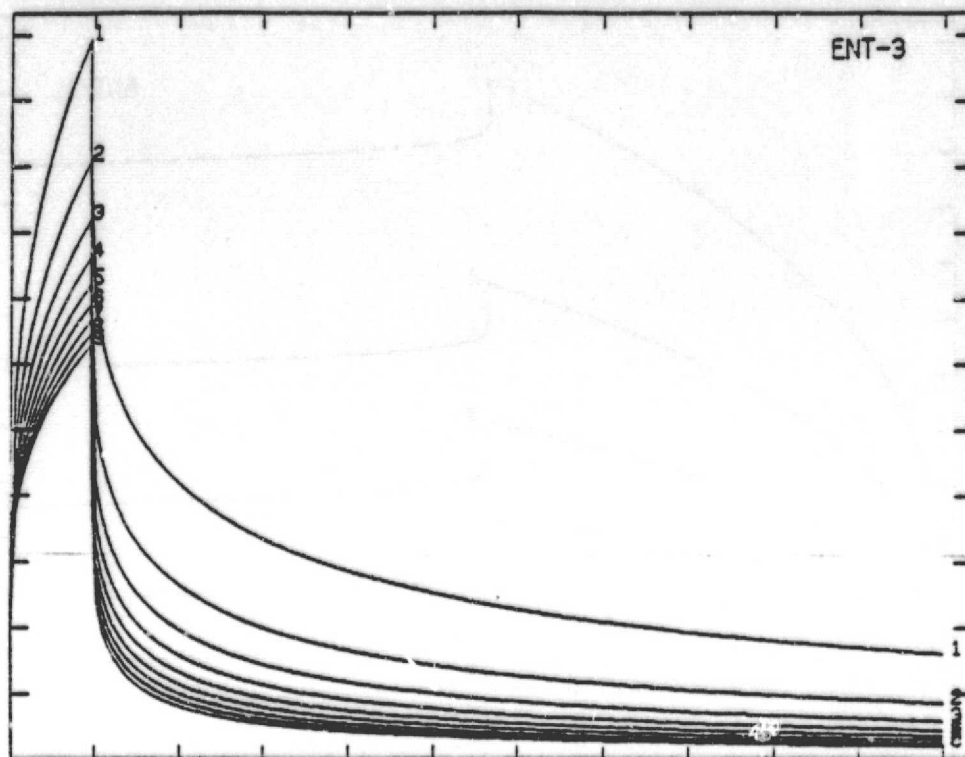


ENT-1 SHORT TIME ENTRY EFFECT

TIME BASE
TOTAL TIME 1.0 HRS
RECOVERY AT 2.5 HRS
INCREMENT OF TIME 0.001 HRS

INPUT VARIABLES

LIST NUMBER	STRESS (PSI)	CU	CT	CG	CT	PT	PR	U	P	ENT
1	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	0.20000
2	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	0.40000
3	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	0.60000
4	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	0.80000
5	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	1.00000
6	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	1.20000
7	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	1.40000
8	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	1.60000
9	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	1.80000
10	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	2.00000
11	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	2.20000
12	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	2.40000
13	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	2.60000
14	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	2.80000
15	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	3.00000
16	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	3.20000
17	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	3.40000
18	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	3.60000
19	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	3.80000
20	2500.	0.167E-05	0.167E-05	1.000	1.000	1.000	0.1333	0.500E 18	-0.500E 01	4.00000



PLOT NUMBER
ENT-3 LONG RECOVERY ENTROPY EFFECT

TIME BASE
TOTAL TIME 109.3 HRS
RECOVERY AT 7.6 HRS
INCREMENT OF TIME 0.2000 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	CU	CT	GU	GT	GZ	EX	B	P	ENT
1	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	0.20000
2	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	0.40000
3	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	0.60000
4	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	0.80000
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	1.00000
6	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	1.20000
7	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	1.40000
8	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	1.60000
9	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 15	-0.500E 01	1.80000
0.220E+01										
0.200E+01										
0.150E+01										
0.140E 01										
0.140E 01										
0.120E+01										
0.100E+01										
0.800E+02										
0.500E+02										
0.400E+02										
0.200E+02										
0.										

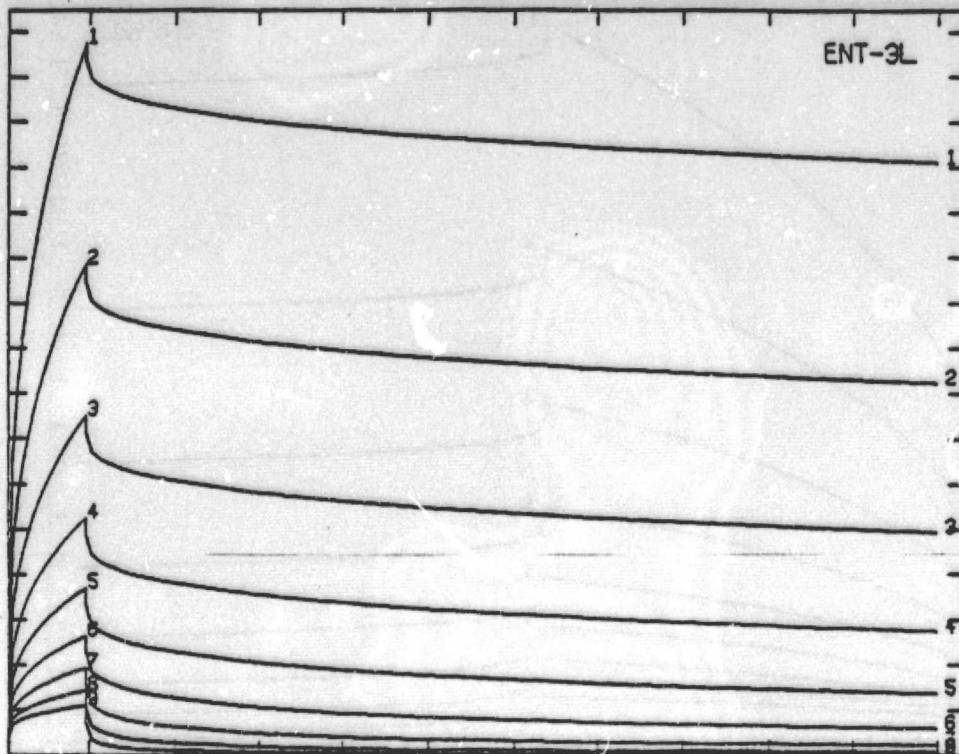
10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0



TIME BASE	
TOTAL TIME	1.2 HRS
RECOVERY AT	0.5 HRS
INCREMENT OF TIME	0.1 HRS

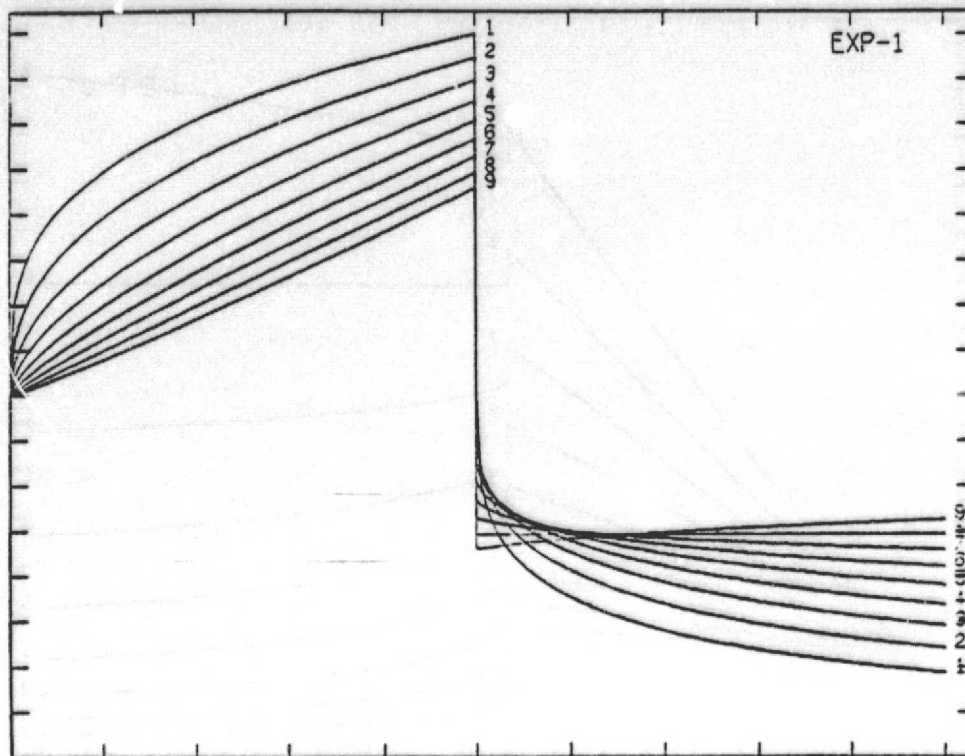
1970/11/24 15:15

LINE	STRESS	CU	CT	CC	CT	CC	EX	B	D	END
WIDEN	(PSI)									
1	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
2	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
3	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
4	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
6	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
7	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
8	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
9	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
10	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
11	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
12	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
13	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
14	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
15	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
16	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
17	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
18	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
19	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
20	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
21	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
22	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
23	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
24	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
25	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
26	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
27	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
28	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
29	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
30	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
31	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
32	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
33	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
34	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
35	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
36	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
37	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
38	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
39	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
40	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
41	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
42	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
43	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
44	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
45	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
46	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
47	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
48	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
49	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
50	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
51	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
52	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
53	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
54	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
55	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
56	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
57	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
58	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
59	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
60	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
61	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
62	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
63	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
64	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
65	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
66	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
67	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
68	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
69	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
70	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
71	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
72	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
73	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
74	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
75	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
76	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
77	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
78	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
79	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
80	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
81	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
82	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
83	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
84	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
85	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
86	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
87	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
88	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
89	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
90	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
91	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
92	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
93	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
94	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
95	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.0000
96	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.50	



PLOT NUMBER											
ENT-3L LARGE DEVIATION ENTROPY-RECOV											
TIME BASE											
TOTAL TIME 100.0 HRS											
RECOVERY AT 0.5 HRS											
INCREMENT OF TIME 0.250 HRS											
INPUT VARIABLES											
LINE STRESS	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	ENT
NUMBER (PSI)											
1	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	3.00032	
2	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	0.00000	
3	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	0.00000	
4	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	0.00000	
5	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	0.00000	
6	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	0.00000	
7	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	0.00000	
8	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	0.00000	
9	2570.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.100E 18	-0.500E 01	0.00000	
0.140E 00											
0.150E 00											
0.160E 00											
0.170E 00											
0.180E 00											
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0.550E 00											
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0.570E 00											
0.580E 00											
0.590E 00											
0.600E 00											
0.610E 00											
0.620E 00											
0.630E 00											
0.640E 00											
0.650E 00											
0.660E 00											
0.670E 00											
0.680E 00											
0.690E 00											
0.700E 00											
0.710E 00											
0.720E 00											
0.730E 00											
0.740E 00											
0.750E 00											
0.760E 00											
0.770E 00											
0.780E 00											
0.790E 00											
0.800E 00											
0.810E 00											
0.820E 00											
0.830E 00											
0.840E 00											
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0.860E 00											
0.870E 00											
0.880E 00											
0.890E 00											
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1.000E 00											

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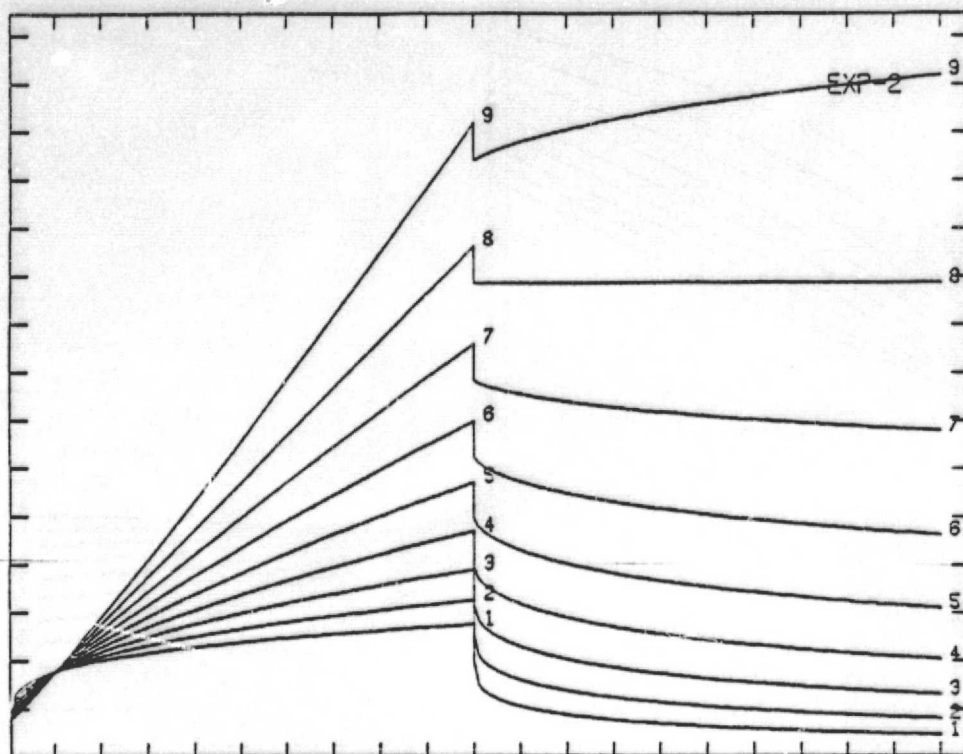


PLOT NUMBER
EXP-1 SHORT TIME EXPONENT FUNCTION

TIME BASE
TOTAL TIME 1.0 HRS
RECOVERY AT 0.5 HRS
INCREMENT OF TIME 0.005 HRS

INPUT VARIABLES

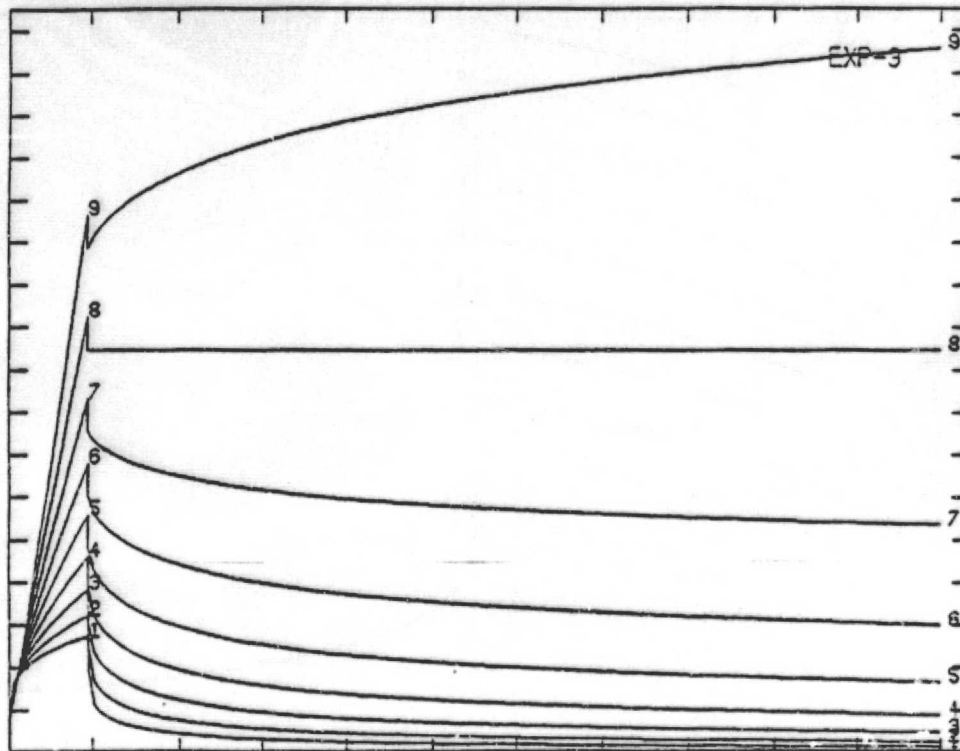
LINE NUMBER--(PSE)	STRESS	C0	C1	G0	G1	G2	EX	B	P	ENT
1	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.5000	0.500E-16	0.500E-01	1.00000
2	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.4000	0.500E-16	0.500E-01	1.00000
3	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3000	0.500E-16	0.500E-01	1.00000
4	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.2000	0.500E-16	0.500E-01	1.00000
5	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.1000	0.500E-16	0.500E-01	1.00000
6	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.0000	0.500E-16	0.500E-01	1.00000
7	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.0000	0.500E-16	0.500E-01	1.00000
8	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	1.0000	0.500E-16	0.500E-01	1.00000
9	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	1.1000	0.500E-16	0.500E-01	1.00000
10	0.800E-02									
11	0.750E-02									
12	0.700E-02									
13	0.650E-02									
14	0.600E-02									
15	0.550E-02									
16	0.500E-02									
17	0.450E-02									
18	0.400E-02									
19	0.350E-02									
20	0.300E-02									
21	0.250E-02									
22	0.200E-02									
23	0.150E-02									
24	0.100E-02									
25	0.000E-02									
26	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0



PLOT NUMBER
EXP-2 MEDIUM EXPONENT FUNCTION

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY ΔT 10.0 HRS
INCREMENT OF TIME 0.100 HRS

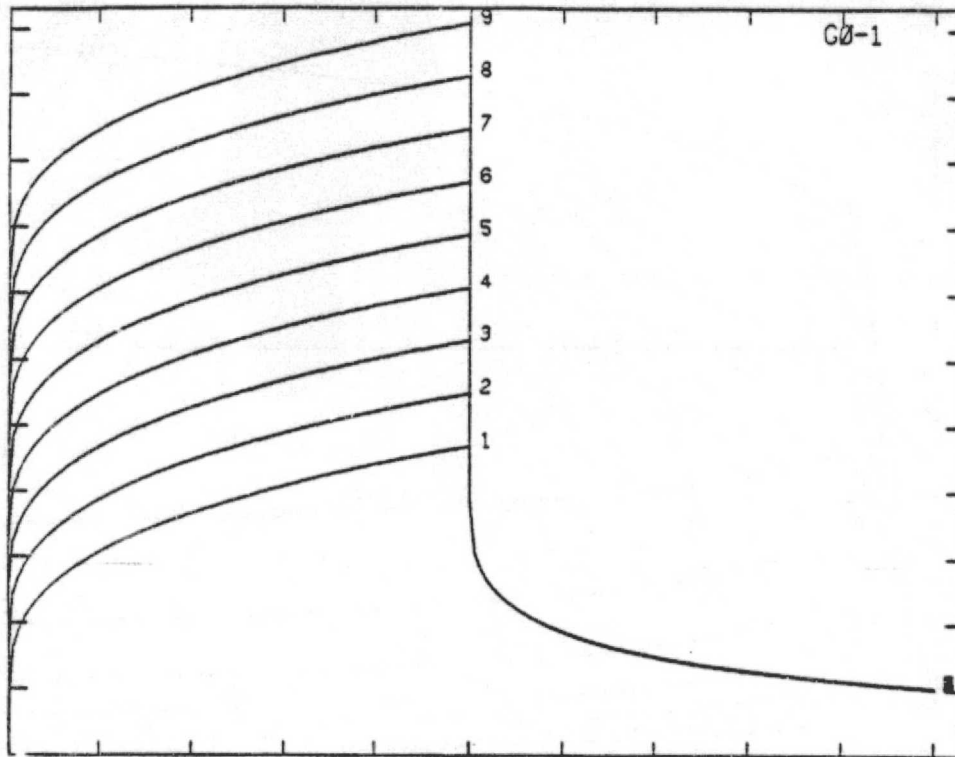
INPUT VARIABLES																				
LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	EX	S	P	ENT										
1	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.5000	0.500E-18	0.500E-01	1.00000										
2	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.4000	0.500E-18	-0.500E-01	1.00000										
3	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.5000	0.500E-18	-0.500E-01	1.00000										
4	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.6000	0.500E-18	-0.500E-01	1.00000										
5	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.7000	0.500E-18	-0.500E-01	1.00000										
6	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.4000	0.500E-18	-0.500E-01	1.00000										
7	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.4000	0.500E-18	-0.500E-01	1.00000										
8	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	1.0000	0.500E-18	-0.500E-01	1.00000										
9	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	1.1000	0.500E-18	-0.500E-01	1.00000										
10	3.750E-01																			
11	0.750E-01																			
12	0.650E-01																			
13	0.670E-01																			
14	0.550E-01																			
15	0.500E-01																			
16	0.450E-01																			
17	0.400E-01																			
18	0.350E-01																			
19	0.300E-01																			
20	0.250E-01																			
21	0.200E-01																			
22	0.150E-01																			
23	0.100E-01																			
24	0.500E-02																			
25	0																			
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0



EXP-3 EXPONENT WITH LONG RECOVERY

TIME BASE
TOTAL TIME 109.5 HRS
RECOVERY AT 9.5 HRS
INCREMENT OF TIME 0.500 HRS

INPUT VARIABLES										
LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	EX	B	P	ENT
1	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	0.5000	0.500E-18	0.500E-01	1.00000
2	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	0.4000	0.500E-18	0.500E-01	1.00010
3	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	0.5000	0.500E-18	0.500E-01	1.00000
4	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	0.6000	0.500E-18	0.500E-01	1.00000
5	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	0.7000	0.500E-18	0.500E-01	1.00000
6	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	0.8000	0.500E-18	0.500E-01	1.00000
7	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	0.9000	0.500E-18	0.500E-01	1.00000
8	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	1.0000	0.500E-18	0.500E-01	1.00000
9	2500	0.100E-05	0.107E-05	1.000	1.000	1.000	1.1000	0.500E-18	0.500E-01	1.00000
10	0.550E-01									
11	0.500E-01									
12	0.750E-01									
13	0.700E-01									
14	0.650E-01									
15	0.600E-01									
16	0.550E-01									
17	0.500E-01									
18	0.450E-01									
19	0.400E-01									
20	0.350E-01									
21	0.300E-01									
22	0.250E-01									
23	0.200E-01									
24	0.150E-01									
25	0.100E-01									
26	0.500E-02									
27	0.									
10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0										

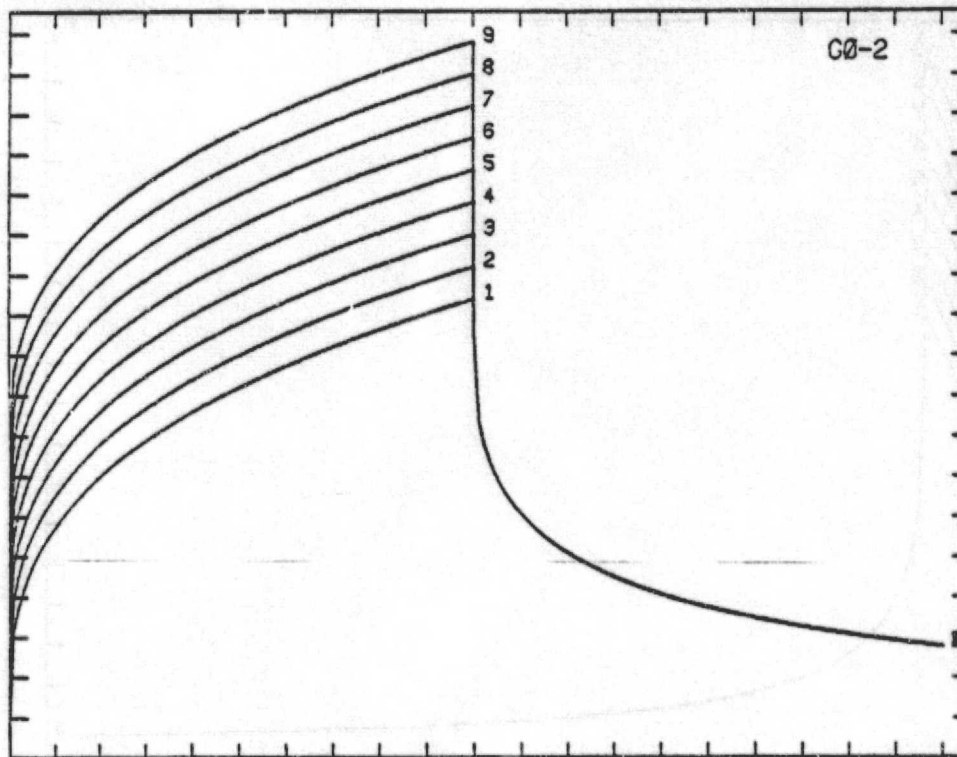


PLOT NUMBER
G0-1 SHORT TIME G0 EFFECT

TIME BASE
TOTAL TIME 1.0 HRS
RECOVERY AT 0.5 HRS
INCREMENT OF TIME 0.005 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	EX	B	P	ENT
1	2500	0.140E-05	0.197E-05	0.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
2	2500	0.140E-05	0.197E-05	0.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
3	2500	0.140E-05	0.197E-05	0.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	2500	0.140E-05	0.197E-05	0.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
5	2500	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
6	2500	0.140E-05	0.197E-05	1.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
7	2500	0.140E-05	0.197E-05	1.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
8	2500	0.140E-05	0.197E-05	1.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	2500	0.140E-05	0.197E-05	1.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
0.110E-01										
0.100E-01										
0.900E-02										
0.800E-02										
0.700E-02										
0.600E-02										
0.500E-02										
0.400E-02										
0.300E-02										
0.200E-02										
0.100E-02										
0.										
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0										

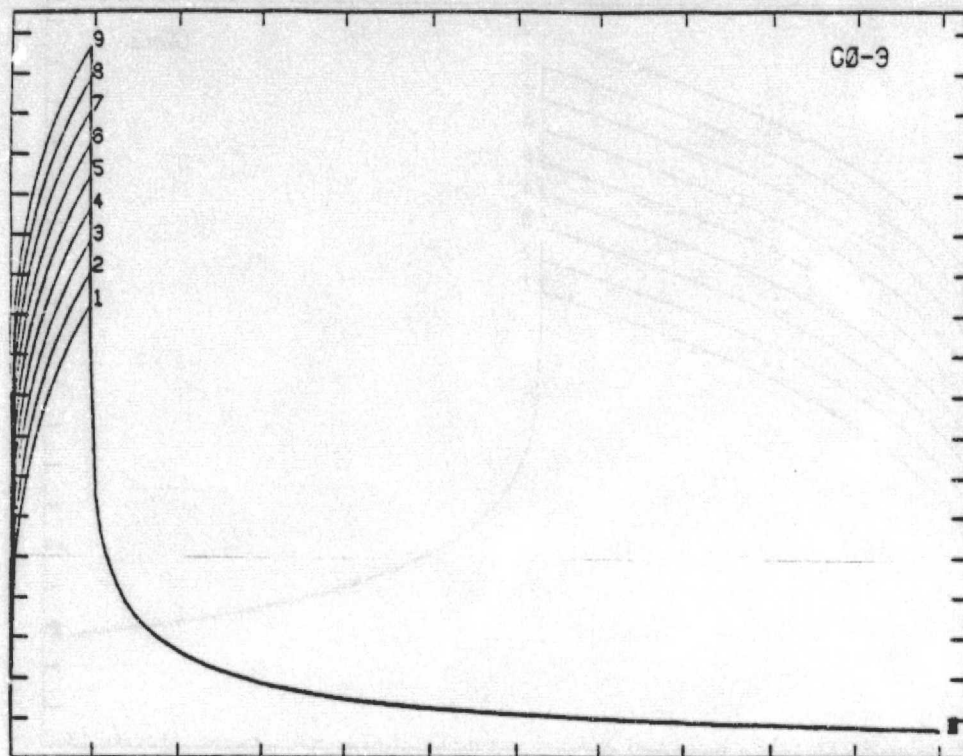


PLOT NUMBER
G0-2 G0 EFFECT WITH LONG RECOVERY

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 10.0 HRS
INCREMENT OF TIME 0.100 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	G0	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	G16	G17	G18	G19	G20
1	2500.	0.160E-05	0.197E-05	0.200	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
2	2500.	0.160E-05	0.197E-05	0.400	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
3	2500.	0.160E-05	0.197E-05	0.600	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
4	2500.	0.160E-05	0.197E-05	0.800	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
6	2500.	0.160E-05	0.197E-05	1.200	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
7	2500.	0.160E-05	0.197E-05	1.400	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
8	2500.	0.160E-05	0.197E-05	1.600	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
9	2500.	0.160E-05	0.197E-05	1.800	1.000	1.000	0.5533	0.500E 18	-0.500E 01	1.00000												
0.160E-01																						
0.172E-01																						
0.183E-01																						
0.193E-01																						
0.160E-01																						
0.130E-01																						
0.123E-01																						
0.110E-01																						
0.103E-01																						
0.970E-02																						
0.800E-02																						
0.700E-02																						
0.600E-02																						
0.500E-02																						
0.400E-02																						
0.300E-02																						
0.200E-02																						
0.100E-02																						
0.																						
1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0			

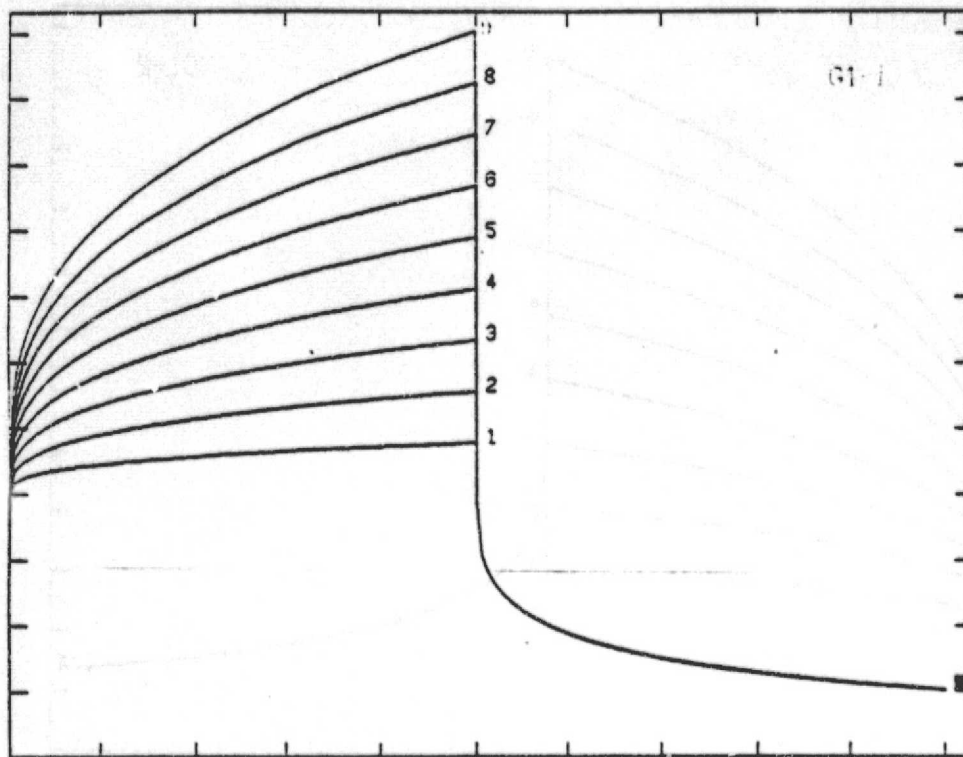


PLOT NUMBER
CO-3 LONG TIME GO EFFECT

TIME BASE
TOTAL TIME 100.0 HRS
RECOVERY AT 0.0 HRS
INCREMENT OF TIME 0.000 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	CO	CT	GO	G1	PG2	EL	U	P	ENT
1	2500	0.160E-05	0.197E-05	0.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
2	2500	0.160E-05	0.197E-05	0.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
3	2500	0.160E-05	0.197E-05	0.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	2500	0.160E-05	0.197E-05	0.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
5	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
6	2500	0.160E-05	0.197E-05	1.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
7	2500	0.160E-05	0.197E-05	1.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
8	2500	0.160E-05	0.197E-05	1.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	2500	0.160E-05	0.197E-05	1.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
10	2500	0.160E-05	0.197E-05	2.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
11	2500	0.160E-05	0.197E-05	2.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
12	2500	0.160E-05	0.197E-05	2.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
13	2500	0.160E-05	0.197E-05	2.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
14	2500	0.160E-05	0.197E-05	2.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
15	2500	0.160E-05	0.197E-05	3.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
16	2500	0.160E-05	0.197E-05	3.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
17	2500	0.160E-05	0.197E-05	3.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
18	2500	0.160E-05	0.197E-05	3.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
19	2500	0.160E-05	0.197E-05	3.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
20	2500	0.160E-05	0.197E-05	4.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
21	2500	0.160E-05	0.197E-05	4.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
22	2500	0.160E-05	0.197E-05	4.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
23	2500	0.160E-05	0.197E-05	4.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
24	2500	0.160E-05	0.197E-05	4.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
25	2500	0.160E-05	0.197E-05	5.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
26	2500	0.160E-05	0.197E-05	5.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
27	2500	0.160E-05	0.197E-05	5.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
28	2500	0.160E-05	0.197E-05	5.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
29	2500	0.160E-05	0.197E-05	5.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
30	2500	0.160E-05	0.197E-05	6.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
31	2500	0.160E-05	0.197E-05	6.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
32	2500	0.160E-05	0.197E-05	6.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
33	2500	0.160E-05	0.197E-05	6.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
34	2500	0.160E-05	0.197E-05	6.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
35	2500	0.160E-05	0.197E-05	7.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
36	2500	0.160E-05	0.197E-05	7.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
37	2500	0.160E-05	0.197E-05	7.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
38	2500	0.160E-05	0.197E-05	7.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
39	2500	0.160E-05	0.197E-05	7.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
40	2500	0.160E-05	0.197E-05	8.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
41	2500	0.160E-05	0.197E-05	8.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
42	2500	0.160E-05	0.197E-05	8.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
43	2500	0.160E-05	0.197E-05	8.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
44	2500	0.160E-05	0.197E-05	8.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
45	2500	0.160E-05	0.197E-05	9.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
46	2500	0.160E-05	0.197E-05	9.200	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
47	2500	0.160E-05	0.197E-05	9.400	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
48	2500	0.160E-05	0.197E-05	9.600	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
49	2500	0.160E-05	0.197E-05	9.800	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
50	2500	0.160E-05	0.197E-05	10.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000

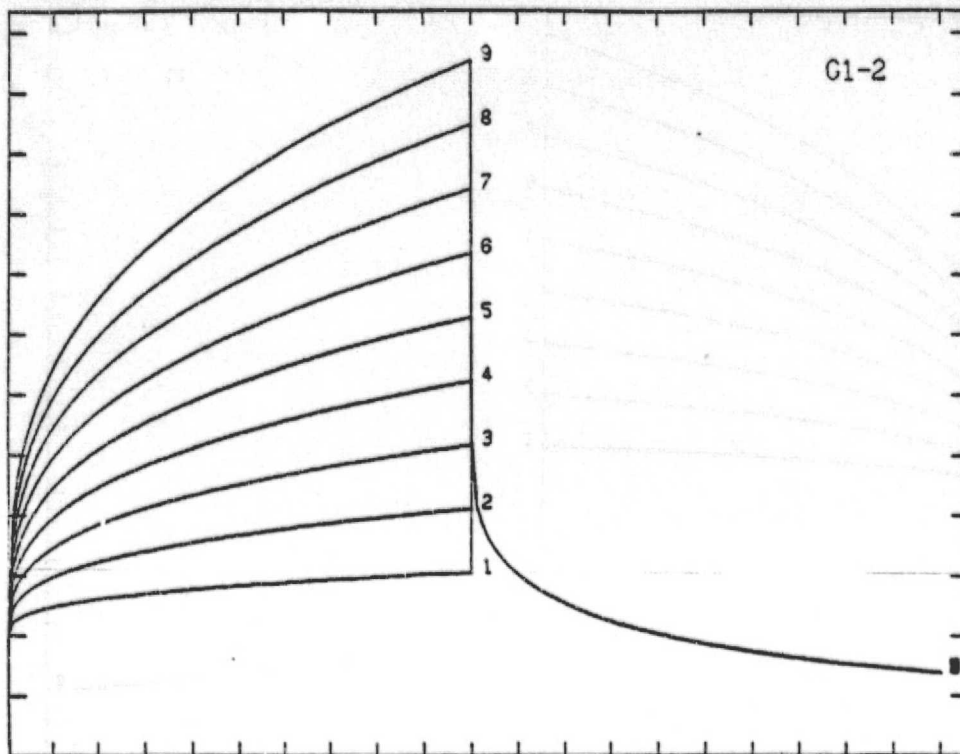


PLOT NUMBER
G1-1 SHORT TIME G1 EFFECT

TIME BASE 1.0 HRS
TOTAL TIME 1.0 HRS
RECOVERY AT 0.5 HRS
INCREMENT OF TIME 0.005 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	G4	G	P	ENT
1	2500	0.160E-05	0.197E-05	1.000	0.200	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
2	2500	0.160E-05	0.197E-05	1.000	0.400	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
3	2500	0.160E-05	0.197E-05	1.000	0.600	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	2500	0.160E-05	0.197E-05	1.000	0.800	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
5	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
6	2500	0.160E-05	0.197E-05	1.000	1.200	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
7	2500	0.160E-05	0.197E-05	1.000	1.400	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
8	2500	0.160E-05	0.197E-05	1.000	1.600	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	2500	0.160E-05	0.197E-05	1.000	1.800	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
10	2500	0.160E-05	0.197E-05	1.000	2.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
11	2500	0.160E-05	0.197E-05	1.000	2.200	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
12	2500	0.160E-05	0.197E-05	1.000	2.400	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
13	2500	0.160E-05	0.197E-05	1.000	2.600	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
14	2500	0.160E-05	0.197E-05	1.000	2.800	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
15	2500	0.160E-05	0.197E-05	1.000	3.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
16	2500	0.160E-05	0.197E-05	1.000	3.200	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
17	2500	0.160E-05	0.197E-05	1.000	3.400	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
18	2500	0.160E-05	0.197E-05	1.000	3.600	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
19	2500	0.160E-05	0.197E-05	1.000	3.800	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
20	2500	0.160E-05	0.197E-05	1.000	4.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000



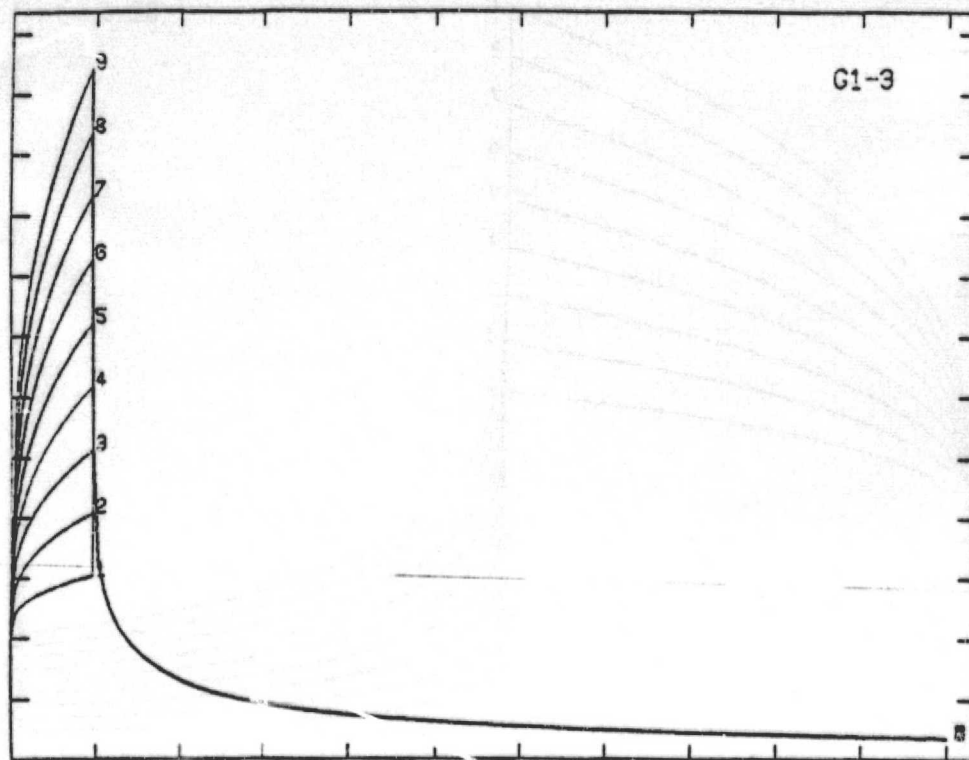
PLOT NUMBER
G1-2 LONG RECOVERY G1 EFFECT

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 10.0 HRS
INCREMENT OF TIME 0.100 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	CT	G0	G1	G2	G3	Z	P	ENT
1	2500	0.140E-05	0.197E-05	1.000	0.200	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
2	2500	0.152E-05	0.197E-05	1.000	0.400	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
3	2500	0.160E-05	0.197E-05	1.000	0.600	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	2500	0.160E-05	0.197E-05	1.000	0.800	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
5	2500	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
6	2500	0.160E-05	0.197E-05	1.000	1.200	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
7	2500	0.160E-05	0.197E-05	1.000	1.400	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
8	2500	0.160E-05	0.197E-05	1.000	1.600	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	2500	0.160E-05	0.197E-05	1.000	1.800	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
0.240E-01										
0.220E-01										
0.200E-01										
0.180E-01										
0.160E-01										
0.140E-01										
0.120E-01										
0.100E-01										
0.800E-02										
0.600E-02										
0.400E-02										
0.200E-02										
0.										
1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0										

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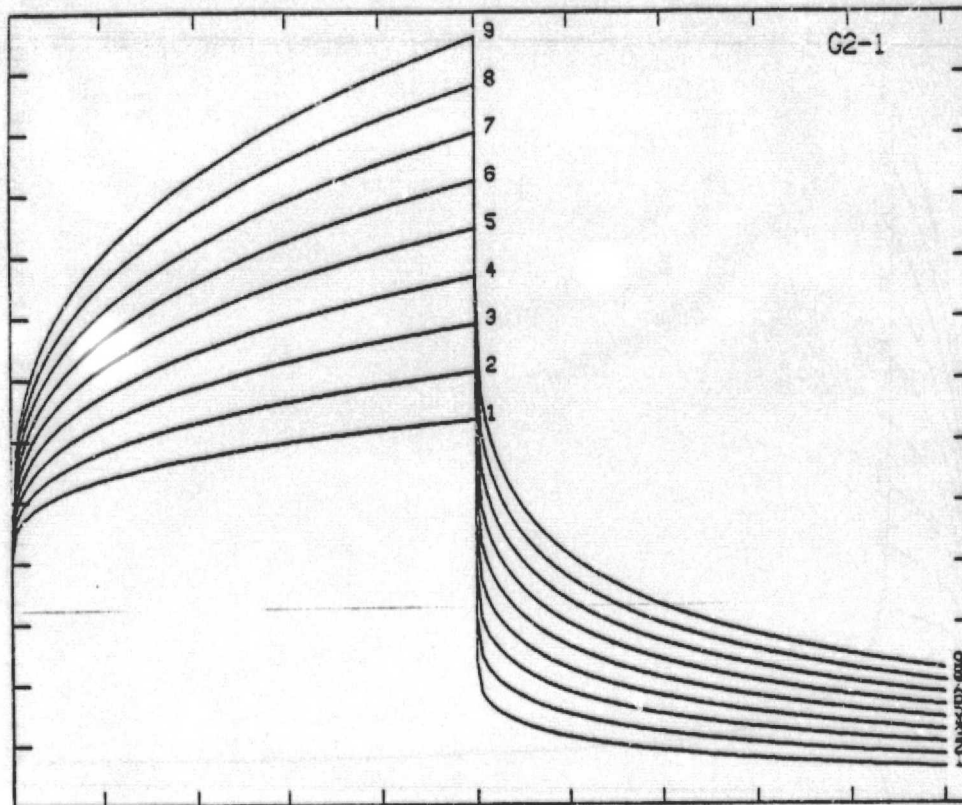


PLOT NUMBER
G1-3 LONG TIME G1 EFFECT

TIME BASE
TOTAL TIME 109.5 HRS
RECOVERY AT 9.5 HRS
INCREMENT OF TIME 0.400 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	EX	B	P	ENT
1	2500.	0.140E-05	0.197E-05	1.000	0.200	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
2	2500.	0.140E-05	0.197E-05	1.000	0.400	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
3	2500.	0.140E-05	0.197E-05	1.000	0.600	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	2500.	0.140E-05	0.197E-05	1.000	0.800	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
5	2500.	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
6	2500.	0.140E-05	0.197E-05	1.000	1.200	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
7	2500.	0.140E-05	0.197E-05	1.000	1.400	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
8	2500.	0.140E-05	0.197E-05	1.000	1.600	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	2500.	0.140E-05	0.197E-05	1.000	1.800	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
0.240E-01										
0.220E-01										
0.200E-01										
0.180E-01										
0.160E-01										
0.140E-01										
0.120E-01										
0.100E-01										
0.800E-02										
0.600E-02										
0.400E-02										
0.200E-02										
0.										
10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0

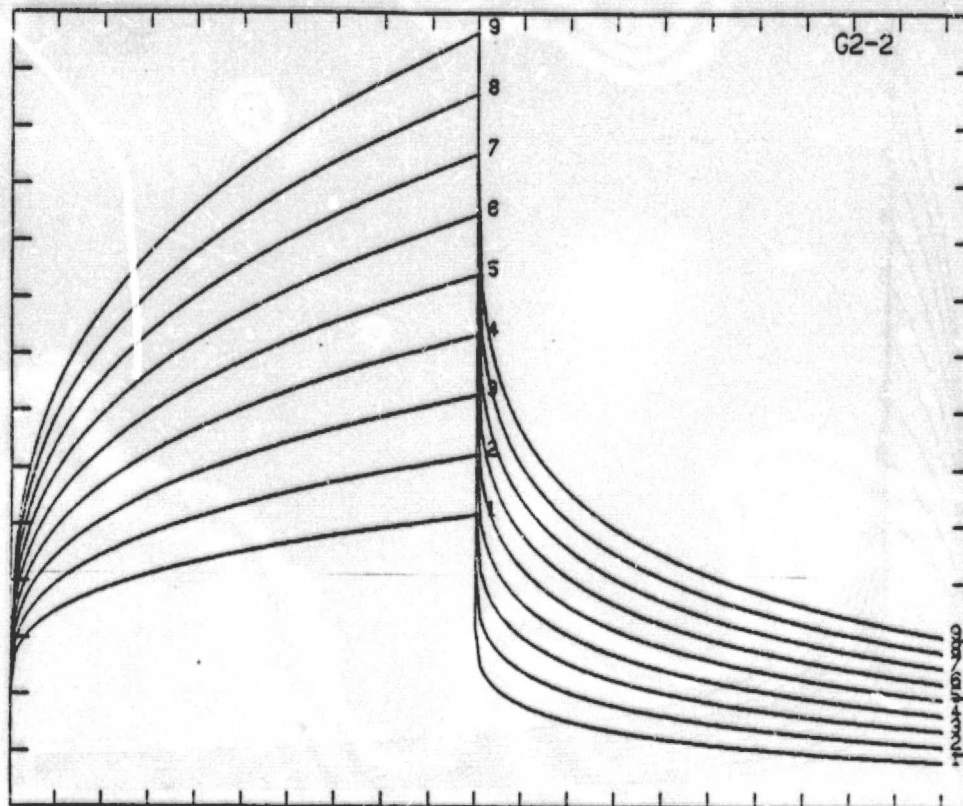


PLOT NUMBER
G2-1 SHORT TIME G2

TIME BASE
TOTAL TIME 1.0 HRS
RECOVERY AT 0.5 HRS
INCREMENT OF TIME 0.005 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	E1	u	P	E1T
1	2500.	0.160E-05	0.197E-05	1.000	1.000	0.600	0.5333	0.500E 14	-0.500E 01	1.00000
2	2500.	0.160E-05	0.197E-05	1.000	1.000	0.800	0.5333	0.500E 14	-0.500E 01	1.00000
3	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.5333	0.500E 14	-0.500E 01	1.00000
4	2500.	0.160E-05	0.197E-05	1.000	1.000	1.200	0.5333	0.500E 14	-0.500E 01	1.00000
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.400	0.5333	0.500E 14	-0.500E 01	1.00000
6	2500.	0.160E-05	0.197E-05	1.000	1.000	1.600	0.5333	0.500E 14	-0.500E 01	1.00000
7	2500.	0.160E-05	0.197E-05	1.000	1.000	1.800	0.5333	0.500E 14	-0.500E 01	1.00000
8	2500.	0.160E-05	0.197E-05	1.000	1.000	2.000	0.5333	0.500E 14	-0.500E 01	1.00000
9	2500.	0.160E-05	0.197E-05	1.000	1.000	2.200	0.5333	0.500E 14	-0.500E 01	1.00000
0.110E-01										
0.120E-01										
0.110E-01										
0.100E-01										
0.900E-02										
0.800E-02										
0.700E-02										
0.600E-02										
0.500E-02										
0.400E-02										
0.300E-02										
0.200E-02										
0.100E-02										



PLOT NUMBER
G2-2 SERIES TIME G2

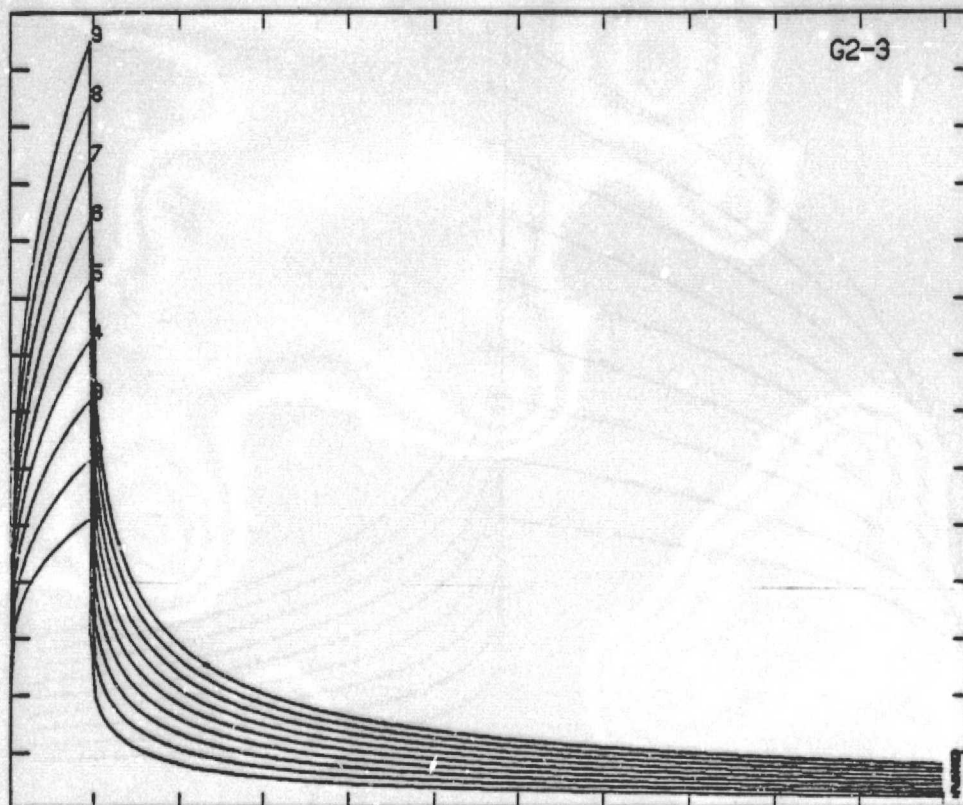
TIME 9.58
TOTAL TIME 20.0 HRS
RECOVER AT 1.00 HRS
INCREMENT OF TIME 0.100 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	E1	H	P	EXT
1	2500.	0.167E-05	0.197E-05	1.000	1.000	0.600	0.3333	0.500E 18	-0.500E 01	1.00000
2	2500.	0.160E-05	0.197E-05	1.000	1.000	0.600	0.3333	0.500E 18	-0.500E 01	1.00000
3	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	2500.	0.160E-05	0.197E-05	1.000	1.000	1.200	0.3333	0.500E 18	-0.500E 01	1.00000
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.400	0.3333	0.500E 18	-0.500E 01	1.00000
6	2500.	0.160E-05	0.197E-05	1.000	1.000	1.600	0.3333	0.500E 18	-0.500E 01	1.00000
7	2500.	0.160E-05	0.197E-05	1.000	1.000	1.800	0.3333	0.500E 18	-0.500E 01	1.00000
8	2500.	0.160E-05	0.197E-05	1.000	1.000	2.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	2500.	0.160E-05	0.197E-05	1.000	1.000	2.200	0.3333	0.500E 18	-0.500E 01	1.00000

0.250E-01
0.260E-01
0.240E-01
0.220E-01
0.200E-01
0.180E-01
0.160E-01
0.140E-01
0.120E-01
0.100E-01
0.800E-02
0.600E-02
0.400E-02
0.200E-02
0.

LINE T-O-O-O LONG

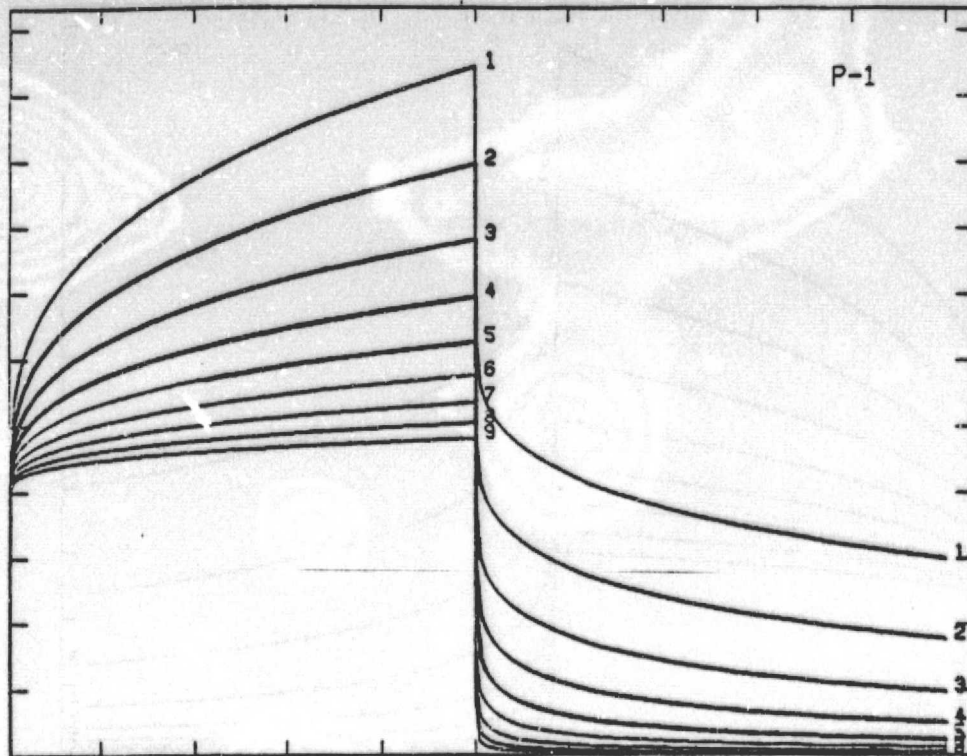


PLOT NUMBER
 G2-3 LONG RECOVERY G2

TIME BASE
 TOTAL TIME 109.8 HRS
 RECOVERY ST 0.6 HRS
 INCREMENT OF TIME 0.500 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	E1	S	P	ENT
1	2500.	0.160E-05	0.197E-05	1.000	1.000	0.500	0.1533	0.500E 18	-0.500E 01	1.00000
2	2500.	0.160E-05	0.197E-05	1.000	1.000	0.500	0.1533	0.500E 18	-0.500E 01	1.00000
3	2500.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.1533	0.500E 18	-0.500E 01	1.00000
4	2500.	0.160E-05	0.197E-05	1.000	1.000	1.200	0.1533	0.500E 18	-0.500E 01	1.00000
5	2500.	0.160E-05	0.197E-05	1.000	1.000	1.400	0.1533	0.500E 18	-0.500E 01	1.00000
6	2500.	0.160E-05	0.197E-05	1.000	1.000	1.600	0.1533	0.500E 18	-0.500E 01	1.00000
7	2500.	0.160E-05	0.197E-05	1.000	1.000	1.800	0.1533	0.500E 18	-0.500E 01	1.00000
8	2500.	0.160E-05	0.197E-05	1.000	1.000	2.000	0.1533	0.500E 18	-0.500E 01	1.00000
9	2500.	0.160E-05	0.197E-05	1.000	1.000	2.200	0.1533	0.500E 18	-0.500E 01	1.00000
0.200E-01										
0.200E-01										
0.200E-01										
0.200E-01										
0.200E-01										
0.180E-01										
0.160E-01										
0.140E-01										
0.120E-01										
0.100E-01										
0.800E-02										
0.600E-02										
0.400E-02										
0.200E-02										
0.										
10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0

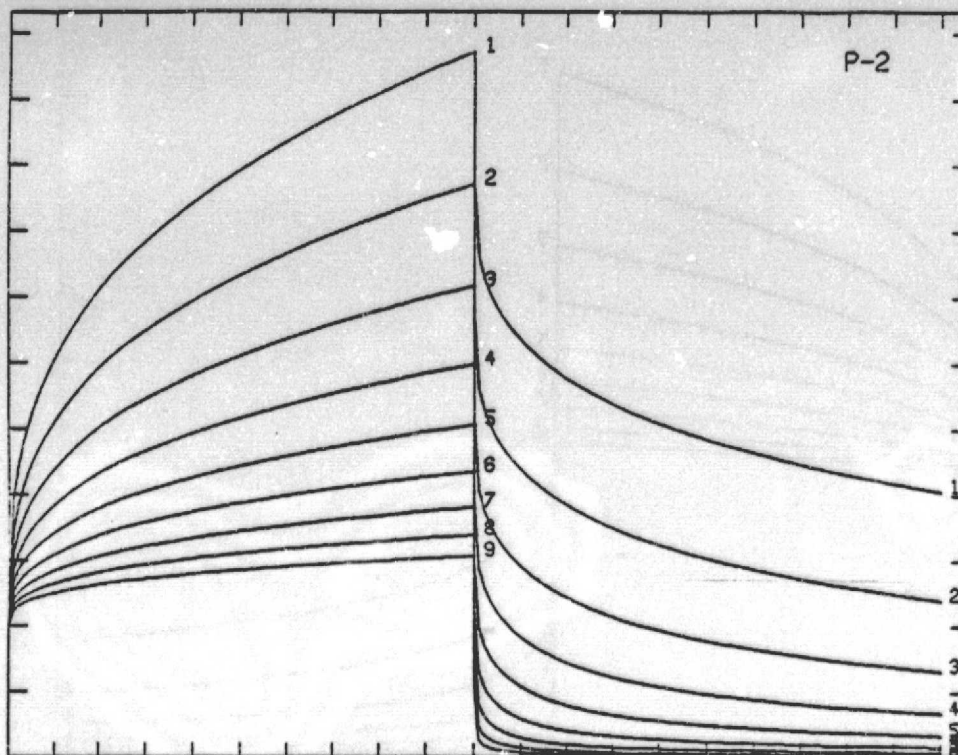


PLOT NUMBER
P-1 VARIATION OF P IN ENT as STRESS = P

TIME BASE 1.0 HRS
TOTAL TIME 1.0 HRS
RECOVERY AT 0.25 HRS
INCREMENT OF TIME 0.005 HRS

INPUT VARIABLES

LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C37	C38	C39	C40	C41	C42	C43	C44	C45	C46	C47	C48	C49	C50	C51	C52	C53	C54	C55	C56	C57	C58	C59	C60	C61	C62	C63	C64	C65	C66	C67	C68	C69	C70	C71	C72	C73	C74	C75	C76	C77	C78	C79	C80	C81	C82	C83	C84	C85	C86	C87	C88	C89	C90	C91	C92	C93	C94	C95	C96	C97	C98	C99	C100	C101	C102	C103	C104	C105	C106	C107	C108	C109	C110	C111	C112	C113	C114	C115	C116	C117	C118	C119	C120	C121	C122	C123	C124	C125	C126	C127	C128	C129	C130	C131	C132	C133	C134	C135	C136	C137	C138	C139	C140	C141	C142	C143	C144	C145	C146	C147	C148	C149	C150	C151	C152	C153	C154	C155	C156	C157	C158	C159	C160	C161	C162	C163	C164	C165	C166	C167	C168	C169	C170	C171	C172	C173	C174	C175	C176	C177	C178	C179	C180	C181	C182	C183	C184	C185	C186	C187	C188	C189	C190	C191	C192	C193	C194	C195	C196	C197	C198	C199	C200	C201	C202	C203	C204	C205	C206	C207	C208	C209	C210	C211	C212	C213	C214	C215	C216	C217	C218	C219	C220	C221	C222	C223	C224	C225	C226	C227	C228	C229	C230	C231	C232	C233	C234	C235	C236	C237	C238	C239	C240	C241	C242	C243	C244	C245	C246	C247	C248	C249	C250	C251	C252	C253	C254	C255	C256	C257	C258	C259	C260	C261	C262	C263	C264	C265	C266	C267	C268	C269	C270	C271	C272	C273	C274	C275	C276	C277	C278	C279	C280	C281	C282	C283	C284	C285	C286	C287	C288	C289	C290	C291	C292	C293	C294	C295	C296	C297	C298	C299	C300	C301	C302	C303	C304	C305	C306	C307	C308	C309	C310	C311	C312	C313	C314	C315	C316	C317	C318	C319	C320	C321	C322	C323	C324	C325	C326	C327	C328	C329	C330	C331	C332	C333	C334	C335	C336	C337	C338	C339	C340	C341	C342	C343	C344	C345	C346	C347	C348	C349	C350	C351	C352	C353	C354	C355	C356	C357	C358	C359	C360	C361	C362	C363	C364	C365	C366	C367	C368	C369	C370	C371	C372	C373	C374	C375	C376	C377	C378	C379	C380	C381	C382	C383	C384	C385	C386	C387	C388	C389	C390	C391	C392	C393	C394	C395	C396	C397	C398	C399	C400	C401	C402	C403	C404	C405	C406	C407	C408	C409	C410	C411	C412	C413	C414	C415	C416	C417	C418	C419	C420	C421	C422	C423	C424	C425	C426	C427	C428	C429	C430	C431	C432	C433	C434	C435	C436	C437	C438	C439	C440	C441	C442	C443	C444	C445	C446	C447	C448	C449	C450	C451	C452	C453	C454	C455	C456	C457	C458	C459	C460	C461	C462	C463	C464	C465	C466	C467	C468	C469	C470	C471	C472	C473	C474	C475	C476	C477	C478	C479	C480	C481	C482	C483	C484	C485	C486	C487	C488	C489	C490	C491	C492	C493	C494	C495	C496	C497	C498	C499	C500	C501	C502	C503	C504	C505	C506	C507	C508	C509	C510	C511	C512	C513	C514	C515	C516	C517	C518	C519	C520	C521	C522	C523	C524	C525	C526	C527	C528	C529	C530	C531	C532	C533	C534	C535	C536	C537	C538	C539	C540	C541	C542	C543	C544	C545	C546	C547	C548	C549	C550	C551	C552	C553	C554	C555	C556	C557	C558	C559	C560	C561	C562	C563	C564	C565	C566	C567	C568	C569	C570	C571	C572	C573	C574	C575	C576	C577	C578	C579	C580	C581	C582	C583	C584	C585	C586	C587	C588	C589	C590	C591	C592	C593	C594	C595	C596	C597	C598	C599	C600	C601	C602	C603	C604	C605	C606	C607	C608	C609	C610	C611	C612	C613	C614	C615	C616	C617	C618	C619	C620	C621	C622	C623	C624	C625	C626	C627	C628	C629	C630	C631	C632	C633	C634	C635	C636	C637	C638	C639	C640	C641	C642	C643	C644	C645	C646	C647	C648	C649	C650	C651	C652	C653	C654	C655	C656	C657	C658	C659	C660	C661	C662	C663	C664	C665	C666	C667	C668	C669	C670	C671	C672	C673	C674	C675	C676	C677	C678	C679	C680	C681	C682	C683	C684	C685	C686	C687	C688	C689	C690	C691	C692	C693	C694	C695	C696	C697	C698	C699	C700	C701	C702	C703	C704	C705	C706	C707	C708	C709	C710	C711	C712	C713	C714	C715	C716	C717	C718	C719	C720	C721	C722	C723	C724	C725	C726	C727	C728	C729	C730	C731	C732	C733	C734	C735	C736	C737	C738	C739	C740	C741	C742	C743	C744	C745	C746	C747	C748	C749	C750	C751	C752	C753	C754	C755	C756	C757	C758	C759	C760	C761	C762	C763	C764	C765	C766	C767	C768	C769	C770	C771	C772	C773	C774	C775	C776	C777	C778	C779	C780	C781	C782	C783	C784	C785	C786	C787	C788	C789	C790	C791	C792	C793	C794	C795	C796	C797	C798	C799	C800	C801	C802	C803	C804	C805	C806	C807	C808	C809	C810	C811	C812	C813	C814	C815	C816	C817	C818	C819	C820	C821	C822	C823	C824	C825	C826	C827	C828	C829	C830	C831	C832	C833	C834	C835	C836	C837	C838	C839	C840	C841	C842	C843	C844	C845	C846	C847	C848	C849	C850	C851	C852	C853	C854	C855	C856	C857	C858	C859	C860	C861	C862	C863	C864	C865	C866	C867	C868	C869	C870	C871	C872	C873	C874	C875	C876	C877	C878	C879	C880	C881	C882	C883	C884	C885	C886	C887	C888	C889	C890	C891	C892	C893	C894	C895	C896	C897	C898	C899	C900	C901	C902	C903	C904	C905	C906	C907	C908	C909	C910	C911	C912	C913	C914	C915	C916	C917	C918	C919	C920	C921	C922	C923	C924	C925	C926	C927	C928	C929	C930	C931	C932	C933	C934	C935	C936	C937	C938	C939	C940	C941	C942	C943	C944	C945	C946	C947	C948	C949	C950	C951	C952	C953	C954	C955	C956	C957	C958	C959	C960	C961	C962	C963	C964	C965	C966	C967	C968	C969	C970	C971	C972	C973	C974	C975	C976	C977	C978	C979	C980	C981	C982	C983	C984	C985	C986	C987	C988	C989	C990	C991	C992	C993	C994	C995	C996	C997	C998	C999
1	2500	0.1600-05	0.1600-05	1.000	1.000	1.000	0.3333	0.5000-10	0.5000-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-01	0.2500-0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						



PLOT NUMBER
P-2 - VARIATION OF ENTROPY WITH STRESS

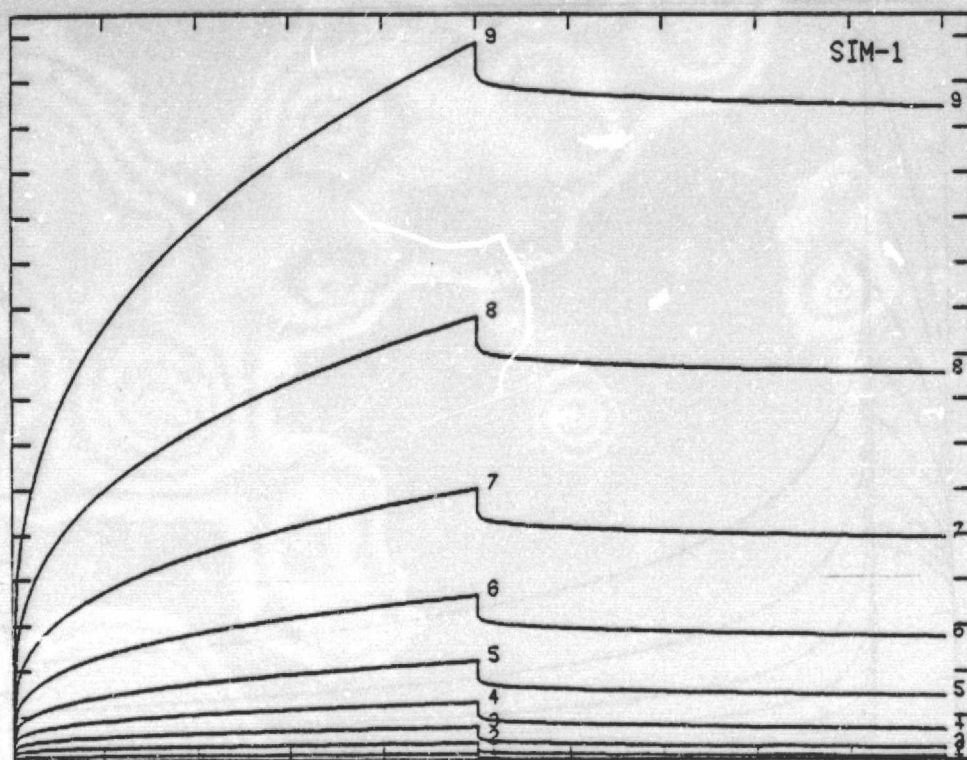
TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 10.0 HRS
INCREMENT OF TIME 0.100 HRS

INPUT VARIABLES

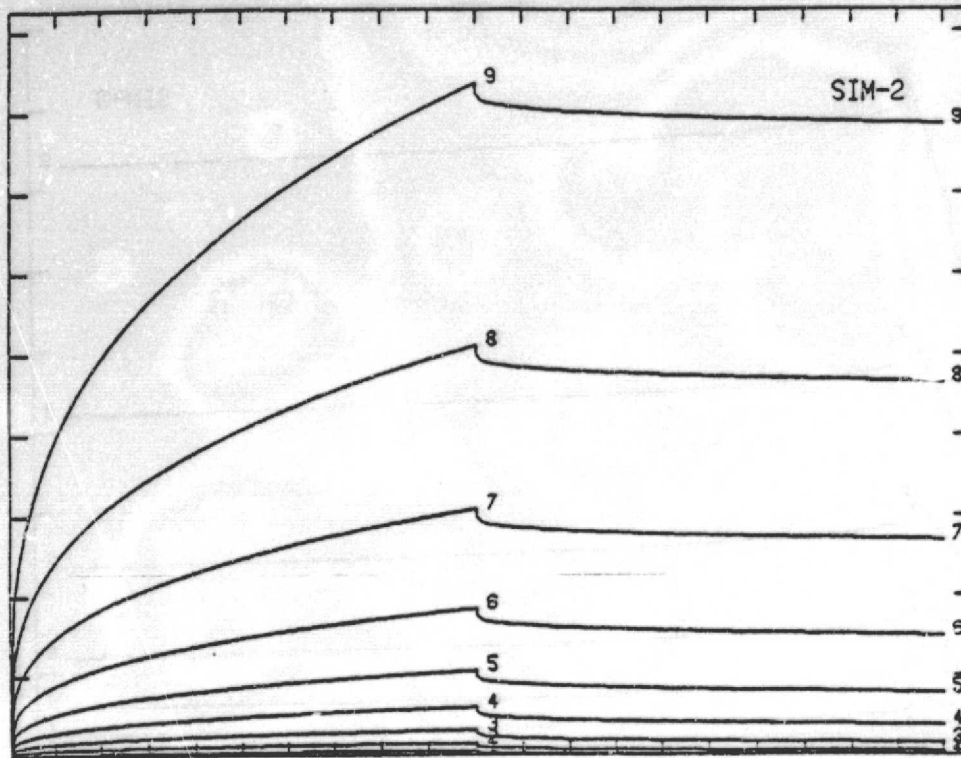
LINE	STRESS	C0	C1	G0	G1	G2	E	D	P	ENT
NUMBER-- (PSI)										
1	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	-0.500E-18	-0.540E-01	0.22592
2	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	0.500E-18	-0.530E-01	0.44955
3	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	-0.500E-18	-0.520E-01	1.37776
4	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	0.500E-18	-0.510E-01	2.56140
5	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	-0.500E-18	-0.500E-01	5.12000
6	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	0.500E-18	-0.490E-01	11.14504
7	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	-0.500E-18	-0.480E-01	24.44266
8	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	0.500E-18	-0.470E-01	53.55544
9	2500	0.140E-05	0.137E-05	1.000	1.000	1.000	0.3333	-0.500E-18	-0.460E-01	117.07327
0.220E-01										
0.200E-01										
0.180E-01										
0.160E-01										
0.140E-01										
0.120E-01										
0.100E-01										
0.080E-01										
0.060E-01										
0.040E-01										
0.020E-01										
0.000E-01										
1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0										

TIME BASE-----
TOTAL TIME 109.5 HRS
RECOVERY-----0.8 HRS
INCREMENT OF TIME 0.600 HRS

213



PCOT NUMBER											
SIM-1 SIMULATE STRESS ENTHROPY ACTION											
TIME BASE											
TOTAL TIME 1.0 HRS											
RECOVERY AT 0.5 HRS											
INCREMENT OF TIME 0.010 HRS											
INPUT VARIABLES											
LINE NUMBER	STRESS (PSI)	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9
1	5000	0.160E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000	
2	1000	0.181E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.00000	
3	1500	0.160E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.00000	
4	2000	0.160E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.00000	
5	2500	0.160E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.00000	
6	3000	0.181E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.00000	
7	3500	0.160E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.00000	
8	4000	0.181E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.00000	
9	4500	0.160E-05	0.197E-15	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	0.00000	
C.1 0.2 C.3 0.4 0.5 0.6 C.7 0.8 0.9 1.0											

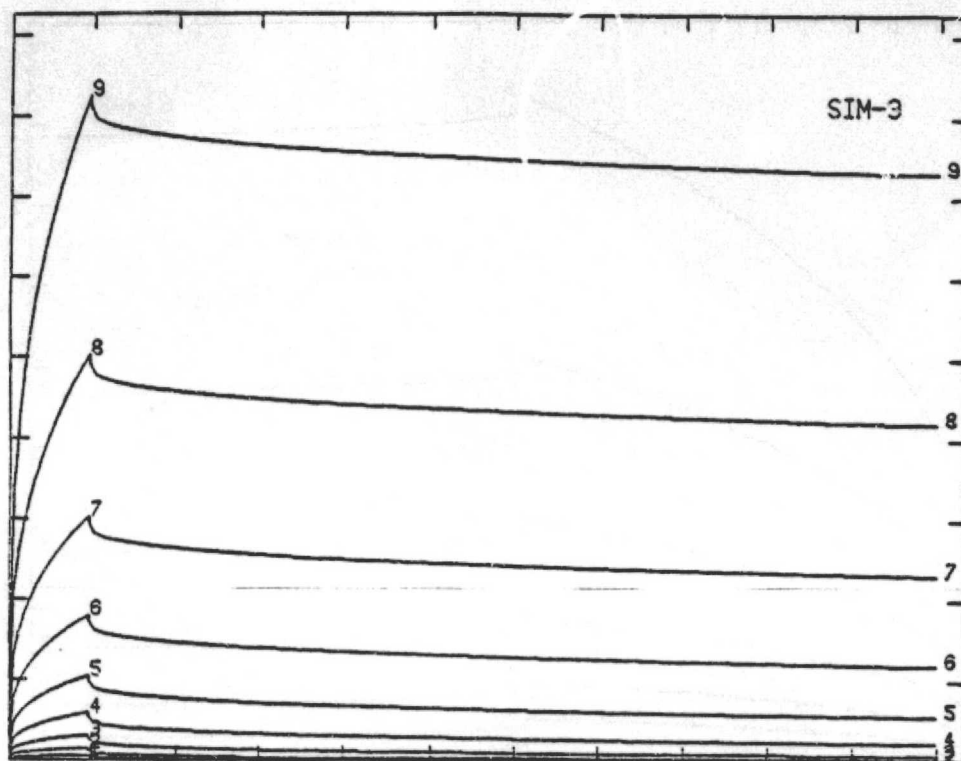


PLOT NUMBER
SIM-2 SIMULATED STRESS-ENTROPY-MEDIU

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 10.0 HRS
INCREMENT OF TIME 0.100 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C37	C38	C39	C40	C41	C42	C43	C44	C45	C46	C47	C48	C49	C50	C51	C52	C53	C54	C55	C56	C57	C58	C59	C60	C61	C62	C63	C64	C65	C66	C67	C68	C69	C70	C71	C72	C73	C74	C75	C76	C77	C78	C79	C80	C81	C82	C83	C84	C85	C86	C87	C88	C89	C90	C91	C92	C93	C94	C95	C96	C97	C98	C99	C100	C101	C102	C103	C104	C105	C106	C107	C108	C109	C110	C111	C112	C113	C114	C115	C116	C117	C118	C119	C120	C121	C122	C123	C124	C125	C126	C127	C128	C129	C130	C131	C132	C133	C134	C135	C136	C137	C138	C139	C140	C141	C142	C143	C144	C145	C146	C147	C148	C149	C150	C151	C152	C153	C154	C155	C156	C157	C158	C159	C160	C161	C162	C163	C164	C165	C166	C167	C168	C169	C170	C171	C172	C173	C174	C175	C176	C177	C178	C179	C180	C181	C182	C183	C184	C185	C186	C187	C188	C189	C190	C191	C192	C193	C194	C195	C196	C197	C198	C199	C200	C201	C202	C203	C204	C205	C206	C207	C208	C209	C210	C211	C212	C213	C214	C215	C216	C217	C218	C219	C220	C221	C222	C223	C224	C225	C226	C227	C228	C229	C230	C231	C232	C233	C234	C235	C236	C237	C238	C239	C240	C241	C242	C243	C244	C245	C246	C247	C248	C249	C250	C251	C252	C253	C254	C255	C256	C257	C258	C259	C260	C261	C262	C263	C264	C265	C266	C267	C268	C269	C270	C271	C272	C273	C274	C275	C276	C277	C278	C279	C280	C281	C282	C283	C284	C285	C286	C287	C288	C289	C290	C291	C292	C293	C294	C295	C296	C297	C298	C299	C300	C301	C302	C303	C304	C305	C306	C307	C308	C309	C310	C311	C312	C313	C314	C315	C316	C317	C318	C319	C320	C321	C322	C323	C324	C325	C326	C327	C328	C329	C330	C331	C332	C333	C334	C335	C336	C337	C338	C339	C340	C341	C342	C343	C344	C345	C346	C347	C348	C349	C350	C351	C352	C353	C354	C355	C356	C357	C358	C359	C360	C361	C362	C363	C364	C365	C366	C367	C368	C369	C370	C371	C372	C373	C374	C375	C376	C377	C378	C379	C380	C381	C382	C383	C384	C385	C386	C387	C388	C389	C390	C391	C392	C393	C394	C395	C396	C397	C398	C399	C400	C401	C402	C403	C404	C405	C406	C407	C408	C409	C410	C411	C412	C413	C414	C415	C416	C417	C418	C419	C420	C421	C422	C423	C424	C425	C426	C427	C428	C429	C430	C431	C432	C433	C434	C435	C436	C437	C438	C439	C440	C441	C442	C443	C444	C445	C446	C447	C448	C449	C450	C451	C452	C453	C454	C455	C456	C457	C458	C459	C460	C461	C462	C463	C464	C465	C466	C467	C468	C469	C470	C471	C472	C473	C474	C475	C476	C477	C478	C479	C480	C481	C482	C483	C484	C485	C486	C487	C488	C489	C490	C491	C492	C493	C494	C495	C496	C497	C498	C499	C500	C501	C502	C503	C504	C505	C506	C507	C508	C509	C510	C511	C512	C513	C514	C515	C516	C517	C518	C519	C520	C521	C522	C523	C524	C525	C526	C527	C528	C529	C530	C531	C532	C533	C534	C535	C536	C537	C538	C539	C540	C541	C542	C543	C544	C545	C546	C547	C548	C549	C550	C551	C552	C553	C554	C555	C556	C557	C558	C559	C560	C561	C562	C563	C564	C565	C566	C567	C568	C569	C570	C571	C572	C573	C574	C575	C576	C577	C578	C579	C580	C581	C582	C583	C584	C585	C586	C587	C588	C589	C590	C591	C592	C593	C594	C595	C596	C597	C598	C599	C600	C601	C602	C603	C604	C605	C606	C607	C608	C609	C610	C611	C612	C613	C614	C615	C616	C617	C618	C619	C620	C621	C622	C623	C624	C625	C626	C627	C628	C629	C630	C631	C632	C633	C634	C635	C636	C637	C638	C639	C640	C641	C642	C643	C644	C645	C646	C647	C648	C649	C650	C651	C652	C653	C654	C655	C656	C657	C658	C659	C660	C661	C662	C663	C664	C665	C666	C667	C668	C669	C670	C671	C672	C673	C674	C675	C676	C677	C678	C679	C680	C681	C682	C683	C684	C685	C686	C687	C688	C689	C690	C691	C692	C693	C694	C695	C696	C697	C698	C699	C700	C701	C702	C703	C704	C705	C706	C707	C708	C709	C710	C711	C712	C713	C714	C715	C716	C717	C718	C719	C720	C721	C722	C723	C724	C725	C726	C727	C728	C729	C730	C731	C732	C733	C734	C735	C736	C737	C738	C739	C740	C741	C742	C743	C744	C745	C746	C747	C748	C749	C750	C751	C752	C753	C754	C755	C756	C757	C758	C759	C760	C761	C762	C763	C764	C765	C766	C767	C768	C769	C770	C771	C772	C773	C774	C775	C776	C777	C778	C779	C780	C781	C782	C783	C784	C785	C786	C787	C788	C789	C790	C791	C792	C793	C794	C795	C796	C797	C798	C799	C800	C801	C802	C803	C804	C805	C806	C807	C808	C809	C810	C811	C812	C813	C814	C815	C816	C817	C818	C819	C820	C821	C822	C823	C824	C825	C826	C827	C828	C829	C830	C831	C832	C833	C834	C835	C836	C837	C838	C839	C840	C841	C842	C843	C844	C845	C846	C847	C848	C849	C850	C851	C852	C853	C854	C855	C856	C857	C858	C859	C860	C861	C862	C863	C864	C865	C866	C867	C868	C869	C870	C871	C872	C873	C874	C875	C876	C877	C878	C879	C880	C881	C882	C883	C884	C885	C886	C887	C888	C889	C890	C891	C892	C893	C894	C895	C896	C897	C898	C899	C900	C901	C902	C903	C904	C905	C906	C907	C908	C909	C910	C911	C912	C913	C914	C915	C916	C917	C918	C919	C920	C921	C922	C923	C924	C925	C926	C927	C928	C929	C930	C931	C932	C933	C934	C935	C936	C937	C938	C939	C940	C941	C942	C943	C944	C945	C946	C947	C948	C949	C950	C951	C952	C953	C954	C955	C956	C957	C958	C959	C960	C961	C962	C963	C964	C965	C966	C967	C968	C969	C970	C971	C972	C973	C974	C975	C976	C977	C978	C979	C980	C981	C982	C983	C984	C985	C986	C987	C988	C989	C990	C991	C992	C993	C994	C995	C996	C997	C998	C999	C1000	C1001	C1002	C1003	C1004	C1005	C1006	C1007	C1008	C1009	C1010	C1011	C1012	C1013	C1014	C1015	C1016	C1017	C1018	C1019	C1020	C1021	C1022	C1023	C1024	C1025	C1026	C1027	C1028	C1029	C1030	C1031	C1032	C1033	C1034	C1035	C1036	C1037	C1038	C1039	C1040	C1041	C1042	C1043	C1044	C1045	C1046	C1047	C1048	C1049	C1050	C1051	C1052	C1053	C1054	C1055	C1056	C1057	C1058	C1059	C1060	C1061	C1062	C1063	C1064	C1065	C1066	C1067	C1068	C1069	C1070	C1071	C1072	C1073	C1074	C1075	C1076	C1077	C1078	C1079	C1080	C1081	C1082	C1083	C1084	C1085	C1086	C1087	C1088	C1089	C1090	C1091	C1092	C1093	C1094	C1095	C1096	C1097	C1098	C1099	C1100	C1101	C1102	C1103	C1104	C1105	C1106	C1107	C1108	C1109	C1110	C1111	C1112	C1113	C1114	C1115	C1116	C1117	C1118	C1119	C1120	C1121	C1122	C1123	C1124	C1125	C1126	C1127	C1128	C1129	C1130	C1131	C1132	C1133	C1134	C1135	C1136	C1137	C1138	C1139	C1140	C1141	C1142	C1143	C1144	C1145	C1146	C1147	C1148	C1149	C1150	C1151	C1152	C1153	C1154	C1155	C1156	C1157	C1158	C1159	C1160	C1161	C1162	C1163	C1164	C1165	C1166	C1167	C1168	C1169	C1170	C1171	C1172	C1173	C1174	C1175	C1176	C1177	C1178	C1179	C1180	C1181	C1182	C1183	C1184	C1185	C1186	C1187	C1188	C1189	C1190	C1191	C1192	C1193	C1194	C1195	C1196	C1197	C1198	C1199	C1200	C1201	C1202	C1203	C1204	C1205	C1206	C1207	C1208	C1209	C1210	C1211	C1212	C1213	C1214	C1215	C1216	C1217	C1218	C1219	C1220	C1221	C1222	C1223	C1224	C1225	C1226	C1227	C1228	C1229	C1230	C1231	C1232	C1233	C1234	C1235	C1236	C1237	C1238	C1239	C1240	C1241	C1242	C1243	C1244	C1245	C1246	C1247	C1248	C1249	C1250	C1251	C1252	C1253	C1254	C1255	C1256	C1257	C1258	C1259	C1260	C1261	C1262	C1263	C1264	C1265	C1266	C1267	C1268	C1269	C1270	C1271	C1272	C1273	C1274	C1275	C1276	C1277	C1278	C1279	C1280	C1281	C1282	C1283	C1284	C1285	C1286	C1287	C1288	C1289	C1290	C1291	C1292	C1293	C1294	C1295	C1296	C1297	C1298	C1299	C1300	C1301	C1302	C1303	C1304	C1305	C1306	C1307	C1308	C1309	C1310	C1311	C1312	C1313	C1314	C1315	C1316	C1317	C1318	C1319	C1320	C1321	C1322	C1323	C1324	C1325	C1326	C1327	C1328	C1329	C1330	C1331	C1332	C1333	C1334	C1335	C1336	C1337	C1338	C1339	C1340	C1341	C1342	C1343	C1344	C1345	C1346	C1347	C1348	C1349	C1350	C1351	C1352	C1353	C1354	C1355	C1356	C1357	C1358	C1359	C1360	C1361	C1362	C1363	C1364	C1365	C1366	C1367	C1368	C1369	C1370	C1371	C1372	C1373	C1374	C1375	C1376	C1377	C1378	C1379	C1380	C1381	C1382	C1383	C1384	C1385	C1386	C1387	C1388	C1389	C1390	C1391	C1392	C1393	C1394	C1395	C1396	C1397	C1398	C1399	C1400	C1401	C1402	C1403	C1404	C1405	C1406	C1407	C1408	C1409	C1410	C1411	C1412	C1413	C1414	C1415	C1416	C1417	C1418	C1419	C1420	C1421	C1422	C1423	C1424	C1425	C1426	C1427	C1428	C1429	C1430	C1431	C1432	C1433	C1434	C1435	C1436	C1437	C1438	C1439	C1440	C1441	C1442	C1443	C1444	C1445	C1446	C1447	C1448	C1449	C1450	C1451	C1452	C1453	C1454	C1455	C1456	C1457	C1458	C1459	C1460	C1461	C1462	C1463	C
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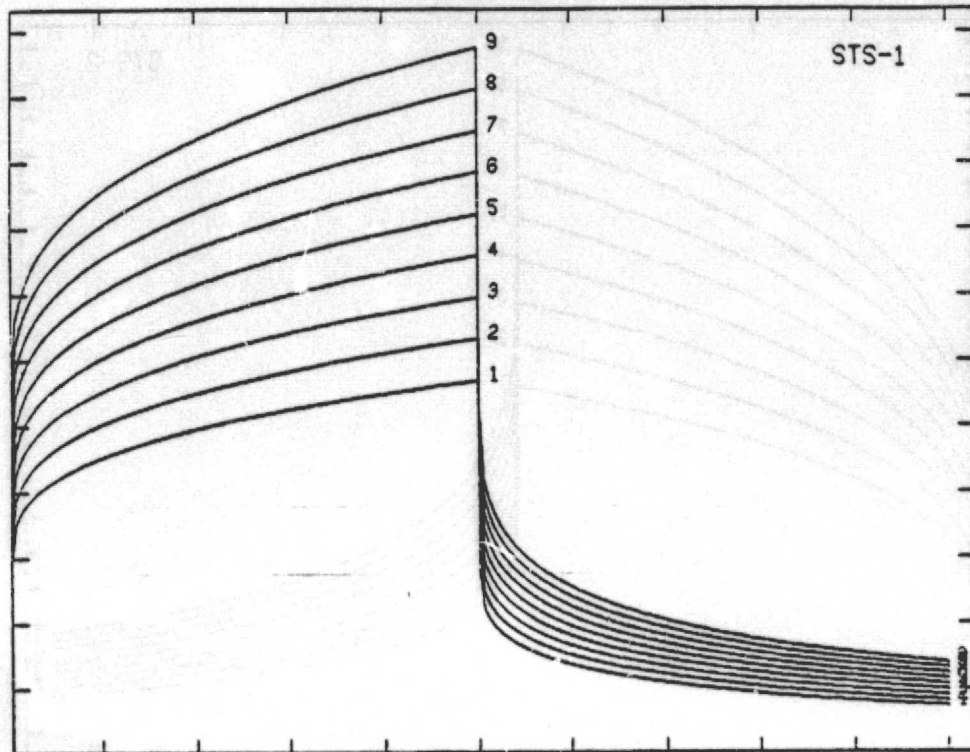


PCOT NUMBER
SIM-3 SIMULATED STRESS-ENTROPY-RECOV

TIME BASE
TOTAL TIME 109.8 HRS
RECOVERY AT 7.6 HRS
INCREMENT UP TIME 0.000 HRS

INPUT VARIABLES

LINE	STRESS	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C37	C38	C39	C40	C41	C42	C43	C44	C45	C46	C47	C48	C49	C50	C51	C52	C53	C54	C55	C56	C57	C58	C59	C60	C61	C62	C63	C64	C65	C66	C67	C68	C69	C70	C71	C72	C73	C74	C75	C76	C77	C78	C79	C80	C81	C82	C83	C84	C85	C86	C87	C88	C89	C90	C91	C92	C93	C94	C95	C96	C97	C98	C99	C100	C101	C102	C103	C104	C105	C106	C107	C108	C109	C110	C111	C112	C113	C114	C115	C116	C117	C118	C119	C120	C121	C122	C123	C124	C125	C126	C127	C128	C129	C130	C131	C132	C133	C134	C135	C136	C137	C138	C139	C140	C141	C142	C143	C144	C145	C146	C147	C148	C149	C150	C151	C152	C153	C154	C155	C156	C157	C158	C159	C160	C161	C162	C163	C164	C165	C166	C167	C168	C169	C170	C171	C172	C173	C174	C175	C176	C177	C178	C179	C180	C181	C182	C183	C184	C185	C186	C187	C188	C189	C190	C191	C192	C193	C194	C195	C196	C197	C198	C199	C200	C201	C202	C203	C204	C205	C206	C207	C208	C209	C210	C211	C212	C213	C214	C215	C216	C217	C218	C219	C220	C221	C222	C223	C224	C225	C226	C227	C228	C229	C230	C231	C232	C233	C234	C235	C236	C237	C238	C239	C240	C241	C242	C243	C244	C245	C246	C247	C248	C249	C250	C251	C252	C253	C254	C255	C256	C257	C258	C259	C260	C261	C262	C263	C264	C265	C266	C267	C268	C269	C270	C271	C272	C273	C274	C275	C276	C277	C278	C279	C280	C281	C282	C283	C284	C285	C286	C287	C288	C289	C290	C291	C292	C293	C294	C295	C296	C297	C298	C299	C300	C301	C302	C303	C304	C305	C306	C307	C308	C309	C310	C311	C312	C313	C314	C315	C316	C317	C318	C319	C320	C321	C322	C323	C324	C325	C326	C327	C328	C329	C330	C331	C332	C333	C334	C335	C336	C337	C338	C339	C340	C341	C342	C343	C344	C345	C346	C347	C348	C349	C350	C351	C352	C353	C354	C355	C356	C357	C358	C359	C360	C361	C362	C363	C364	C365	C366	C367	C368	C369	C370	C371	C372	C373	C374	C375	C376	C377	C378	C379	C380	C381	C382	C383	C384	C385	C386	C387	C388	C389	C390	C391	C392	C393	C394	C395	C396	C397	C398	C399	C400	C401	C402	C403	C404	C405	C406	C407	C408	C409	C410	C411	C412	C413	C414	C415	C416	C417	C418	C419	C420	C421	C422	C423	C424	C425	C426	C427	C428	C429	C430	C431	C432	C433	C434	C435	C436	C437	C438	C439	C440	C441	C442	C443	C444	C445	C446	C447	C448	C449	C450	C451	C452	C453	C454	C455	C456	C457	C458	C459	C460	C461	C462	C463	C464	C465	C466	C467	C468	C469	C470	C471	C472	C473	C474	C475	C476	C477	C478	C479	C480	C481	C482	C483	C484	C485	C486	C487	C488	C489	C490	C491	C492	C493	C494	C495	C496	C497	C498	C499	C500	C501	C502	C503	C504	C505	C506	C507	C508	C509	C510	C511	C512	C513	C514	C515	C516	C517	C518	C519	C520	C521	C522	C523	C524	C525	C526	C527	C528	C529	C530	C531	C532	C533	C534	C535	C536	C537	C538	C539	C540	C541	C542	C543	C544	C545	C546	C547	C548	C549	C550	C551	C552	C553	C554	C555	C556	C557	C558	C559	C560	C561	C562	C563	C564	C565	C566	C567	C568	C569	C570	C571	C572	C573	C574	C575	C576	C577	C578	C579	C580	C581	C582	C583	C584	C585	C586	C587	C588	C589	C590	C591	C592	C593	C594	C595	C596	C597	C598	C599	C600	C601	C602	C603	C604	C605	C606	C607	C608	C609	C610	C611	C612	C613	C614	C615	C616	C617	C618	C619	C620	C621	C622	C623	C624	C625	C626	C627	C628	C629	C630	C631	C632	C633	C634	C635	C636	C637	C638	C639	C640	C641	C642	C643	C644	C645	C646	C647	C648	C649	C650	C651	C652	C653	C654	C655	C656	C657	C658	C659	C660	C661	C662	C663	C664	C665	C666	C667	C668	C669	C670	C671	C672	C673	C674	C675	C676	C677	C678	C679	C680	C681	C682	C683	C684	C685	C686	C687	C688	C689	C690	C691	C692	C693	C694	C695	C696	C697	C698	C699	C700	C701	C702	C703	C704	C705	C706	C707	C708	C709	C710	C711	C712	C713	C714	C715	C716	C717	C718	C719	C720	C721	C722	C723	C724	C725	C726	C727	C728	C729	C730	C731	C732	C733	C734	C735	C736	C737	C738	C739	C740	C741	C742	C743	C744	C745	C746	C747	C748	C749	C750	C751	C752	C753	C754	C755	C756	C757	C758	C759	C760	C761	C762	C763	C764	C765	C766	C767	C768	C769	C770	C771	C772	C773	C774	C775	C776	C777	C778	C779	C780	C781	C782	C783	C784	C785	C786	C787	C788	C789	C790	C791	C792	C793	C794	C795	C796	C797	C798	C799	C800	C801	C802	C803	C804	C805	C806	C807	C808	C809	C810	C811	C812	C813	C814	C815	C816	C817	C818	C819	C820	C821	C822	C823	C824	C825	C826	C827	C828	C829	C830	C831	C832	C833	C834	C835	C836	C837	C838	C839	C840	C841	C842	C843	C844	C845	C846	C847	C848	C849	C850	C851	C852	C853	C854	C855	C856	C857	C858	C859	C860	C861	C862	C863	C864	C865	C866	C867	C868	C869	C870	C871	C872	C873	C874	C875	C876	C877	C878	C879	C880	C881	C882	C883	C884	C885	C886	C887	C888	C889	C890	C891	C892	C893	C894	C895	C896	C897	C898	C899	C900	C901	C902	C903	C904	C905	C906	C907	C908	C909	C910	C911	C912	C913	C914	C915	C916	C917	C918	C919	C920	C921	C922	C923	C924	C925	C926	C927	C928	C929	C930	C931	C932	C933	C934	C935	C936	C937	C938	C939	C940	C941	C942	C943	C944	C945	C946	C947	C948	C949	C950	C951	C952	C953	C954	C955	C956	C957	C958	C959	C960	C961	C962	C963	C964	C965	C966	C967	C968	C969	C970	C971	C972	C973	C974	C975	C976	C977	C978	C979	C980	C981	C982	C983	C984	C985	C986	C987	C988	C989	C990	C991	C992	C993	C994	C995	C996	C997	C998	C999	C1000	C1001	C1002	C1003	C1004	C1005	C1006	C1007	C1008	C1009	C1010	C1011	C1012	C1013	C1014	C1015	C1016	C1017	C1018	C1019	C1020	C1021	C1022	C1023	C1024	C1025	C1026	C1027	C1028	C1029	C1030	C1031	C1032	C1033	C1034	C1035	C1036	C1037	C1038	C1039	C1040	C1041	C1042	C1043	C1044	C1045	C1046	C1047	C1048	C1049	C1050	C1051	C1052	C1053	C1054	C1055	C1056	C1057	C1058	C1059	C1060	C1061	C1062	C1063	C1064	C1065	C1066	C1067	C1068	C1069	C1070	C1071	C1072	C1073	C1074	C1075	C1076	C1077	C1078	C1079	C1080	C1081	C1082	C1083	C1084	C1085	C1086	C1087	C1088	C1089	C1090	C1091	C1092	C1093	C1094	C1095	C1096	C1097	C1098	C1099	C1100	C1101	C1102	C1103	C1104	C1105	C1106	C1107	C1108	C1109	C1110	C1111	C1112	C1113	C1114	C1115	C1116	C1117	C1118	C1119	C1120	C1121	C1122	C1123	C1124	C1125	C1126	C1127	C1128	C1129	C1130	C1131	C1132	C1133	C1134	C1135	C1136	C1137	C1138	C1139	C1140	C1141	C1142	C1143	C1144	C1145	C1146	C1147	C1148	C1149	C1150	C1151	C1152	C1153	C1154	C1155	C1156	C1157	C1158	C1159	C1160	C1161	C1162	C1163	C1164	C1165	C1166	C1167	C1168	C1169	C1170	C1171	C1172	C1173	C1174	C1175	C1176	C1177	C1178	C1179	C1180	C1181	C1182	C1183	C1184	C1185	C1186	C1187	C1188	C1189	C1190	C1191	C1192	C1193	C1194	C1195	C1196	C1197	C1198	C1199	C1200	C1201	C1202	C1203	C1204	C1205	C1206	C1207	C1208	C1209	C1210	C1211	C1212	C1213	C1214	C1215	C1216	C1217	C1218	C1219	C1220	C1221	C1222	C1223	C1224	C1225	C1226	C1227	C1228	C1229	C1230	C1231	C1232	C1233	C1234	C1235	C1236	C1237	C1238	C1239	C1240	C1241	C1242	C1243	C1244	C1245	C1246	C1247	C1248	C1249	C1250	C1251	C1252	C1253	C1254	C1255	C1256	C1257	C1258	C1259	C1260	C1261	C1262	C1263	C1264	C1265	C1266	C1267	C1268	C1269	C1270	C1271	C1272	C1273	C1274	C1275	C1276	C1277	C1278	C1279	C1280	C1281	C1282	C1283	C1284	C1285	C1286	C1287	C1288	C1289	C1290	C1291	C1292	C1293	C1294	C1295	C1296	C1297	C1298	C1299	C1300	C1301	C1302	C1303	C1304	C1305	C1306	C1307	C1308	C1309	C1310	C1311	C1312	C1313	C1314	C1315	C1316	C1317	C1318	C1319	C1320	C1321	C1322	C1323	C1324	C1325	C1326	C1327	C1328	C1329	C1330	C1331	C1332	C1333	C1334	C1335	C1336	C1337	C1338	C1339	C1340	C1341	C1342	C1343	C1344	C1345	C1346	C1347	C1348	C1349	C1350	C1351	C1352	C1353	C1354	C1355	C1356	C1357	C1358	C1359	C1360	C1361	C1362	C1363	C1364	C1365	C1366	C1367	C1368	C1369	C1370	C1371	C1372	C1373	C1374	C1375	C1376	C1377	C1378	C1379	C1380	C1381	C1382	C1383	C1384	C1385	C1386	C1387	C1388	C1389	C1390	C1391	C1392	C1393	C1394	C1395	C1396	C1397	C1398	C1399	C1400	C1401	C1402	C1403	C1404	C1405	C1406	C1407	C1408	C1409	C1410	C1411	C1412	C1413	C1414	C1415	C1416	C1417	C1418	C1419	C1420	C1421	C1422	C1423	C1424	C1425	C1426	C1427	C1428	C1429	C1430	C1431	C1432	C1433	C1434	C1435	C1436	C1437	C1438	C1439	C1440	C1441	C1442	C1443	C1444	C1445	C1446	C1447	C1448	C1449	C1450	C1451	C1452	C1453	C1454	C1455	C1456	C1457	C1458	C1459	C1460	C1461	C1462	C1463	C1464	C1465	C1466	C
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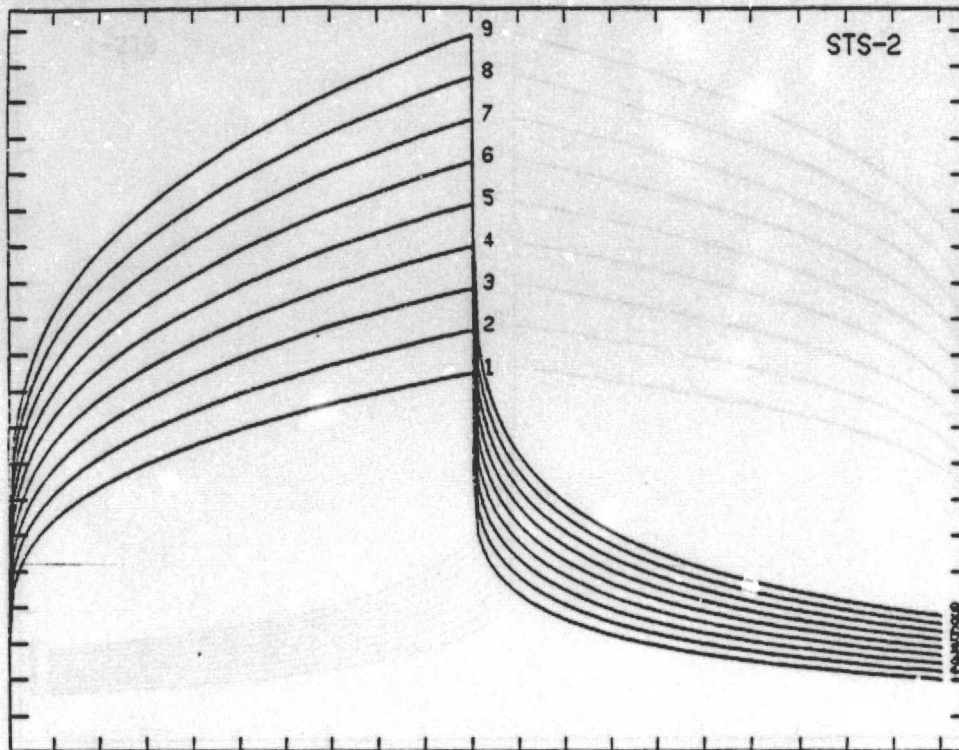


PLOT NUMBER
STS-1 STRESS FUNCTION SHORT TIME

TIME BASE
TOTAL TIME 1.0 HRS
RECOVERY AT 0.5 HRS
INCREMENT OF TIME 0.005 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	E4	S	P	INT
1	1000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.577E 18	-0.500E 01	1.00000
2	2000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
3	3000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	4000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
5	5000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
6	6000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
7	7000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
8	8000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	9000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
0.110E-01										
0.100E-01										
0.200E-02										
0.300E-02										
0.400E-02										
0.500E-02										
0.600E-02										
0.700E-02										
0.800E-02										
0.900E-02										
0.100E-02										
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	

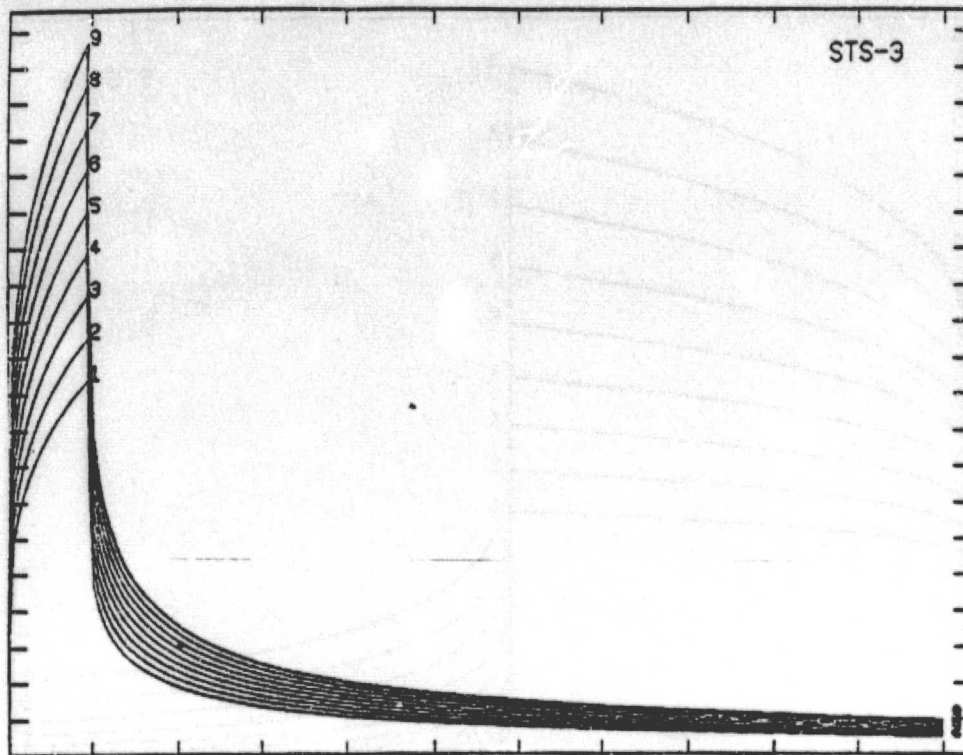


PLOT NUMBER
STS-2 STRESS FUNCT. LONG TIME

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 10.0 HRS
INCREMENT OF TIME 0.100 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	E1	B	P	ENT									
1	1400	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
2	2000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
3	2200	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
4	2400	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
5	2600	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
6	2800	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
7	3000	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
8	3200	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
9	3400	0.140E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.30000									
0.200E-01																			
0.190E-01																			
0.180E-01																			
0.170E-01																			
0.160E-01																			
0.150E-01																			
0.140E-01																			
0.130E-01																			
0.120E-01																			
0.110E-01																			
0.100E-01																			
0.900E-02																			
0.800E-02																			
0.700E-02																			
0.600E-02																			
0.500E-02																			
0.400E-02																			
0.300E-02																			
0.200E-02																			
0.100E-02																			
0.																			
1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0

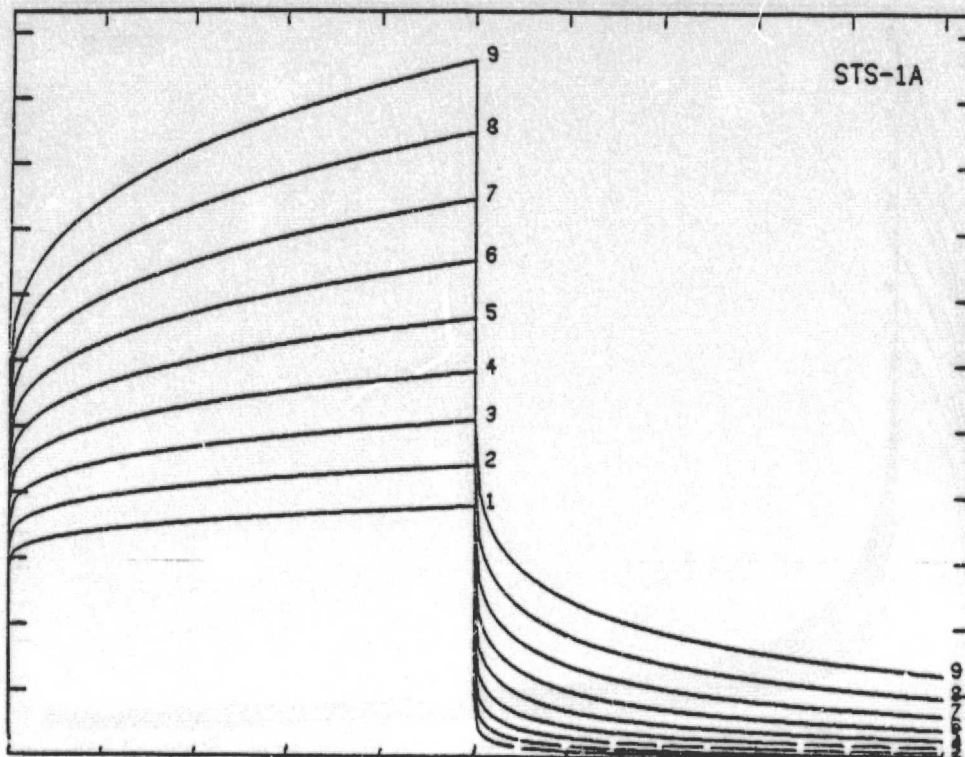


PLU# NUMBER
STS-3 STRESS FUNCT. LONG RECOVERY

TIME BASE
TOTAL TIME 100.0 HRS
RECOVERY AT 9.5 HRS
INCREMENT OF TIME 0.600 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	E1	S	P	ENT
1	1800	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
2	2000	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
3	2200	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
4	2400	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
5	2600	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
6	2800	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
7	3000	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
8	3200	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
9	3400	0.160E-01	0.197E-05	1.000	1.000	1.000	0.3333	0.500E 18	-0.500E 01	1.00000
0	0.277E-01									
	0.197E-01									
	0.160E-01									
	0.170E-01									
	0.161E-01									
	0.151E-01									
	0.140E-01									
	0.110E-01									
	0.122E-01									
	0.117E-01									
	0.100E-01									
	0.300E-02									
	0.401E-02									
	0.700E-02									
	0.600E-02									
	0.507E-02									
	0.407E-02									
	0.371E-02									
	0.200E-02									
	0.100E-02									
	0.									
	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	100.0	110.0

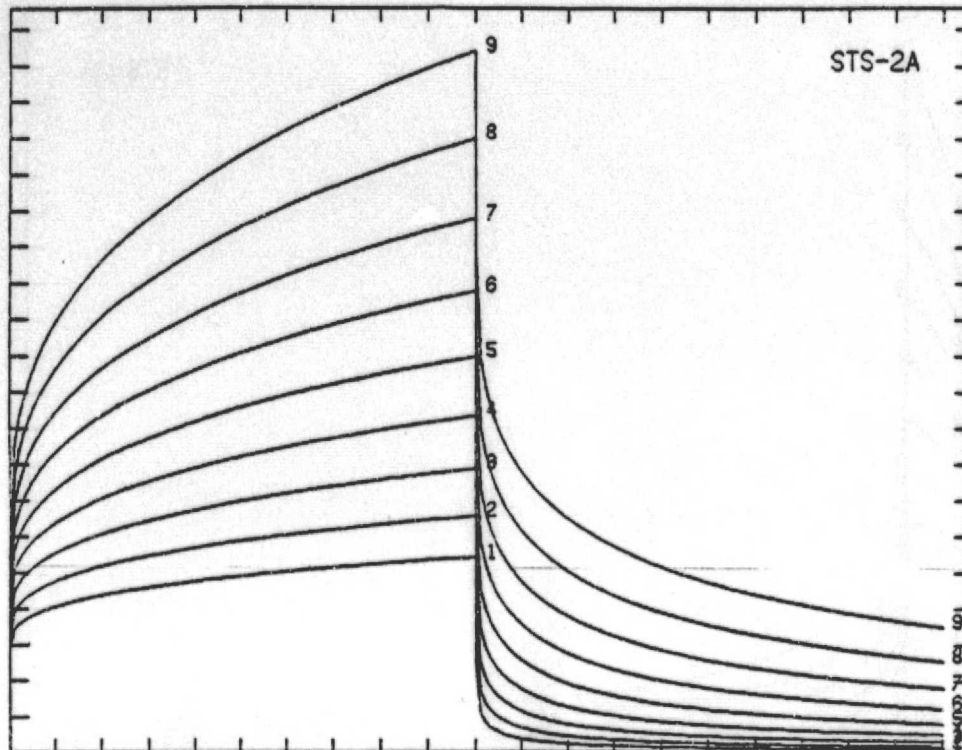


PLOT NUMBER
STS-1A STRESS WITH ENTRAPPED SHORT

TIME BASE
TOTAL TIME 1.0 HRS
RECOVERY AT 0.5 HRS
INCREMENT OF TIME 0.005 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (HSE)	C0	C1	G0	G1	'S2	E4	3	P	ENT
1	1400.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-0.500E 01	25.66197
2	2000.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-0.500E 01	15.62500
3	2200.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-0.500E 01	2.70149
4	2400.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-0.500E 01	6.27754
5	2600.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-1.500E 01	4.27027
6	2800.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-2.500E 01	2.70523
7	3000.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-3.500E 01	2.35751
8	3200.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-4.500E 01	1.47012
9	3400.	0.160E-05	0.197E-05	1.000	1.000	1.000	0.3333	0.570E 18	-5.500E 01	1.10246
0.170E-01										
0.170E-01										
0.400E-02										
0.500E-02										
0.700E-02										
0.600E-02										
0.500E-02										
0.400E-02										
0.300E-02										
0.200E-02										
0.100E-02										
0.										
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0										

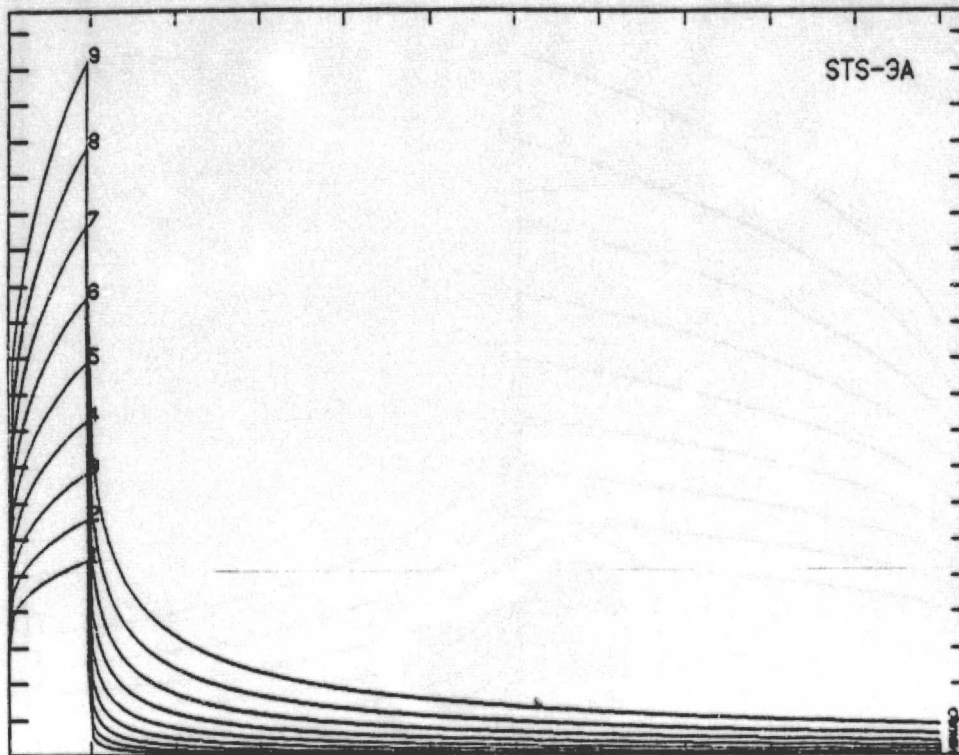


PLOT NUMBER
STS-2A STRESS WITH ENTROPY LONG

TIME BASE
TOTAL TIME 20.0 HRS
RECOVERY AT 12.0 HRS
INCREMENT OF TIME 0.100 HRS

INPUT VARIABLES

LINE NUMBER	STRESS (PSI)	C0	C1	G0	G1	G2	E4	B	P	ENT									
1	1477	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	24.45127									
2	2200	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	15.62570									
3	2200	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	2.71189									
4	2400	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	6.27934									
5	2400	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	4.27527									
6	1800	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	2.71523									
7	1000	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	2.25751									
8	1200	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	1.44012									
9	1400	0.140E-05	0.197E-05	1.000	1.000	1.000	2.5553	0.500E 18	-0.500E 01	1.10246									
0.250E-01																			
0.150E-01																			
0.175E-01																			
0.165E-01																			
0.155E-01																			
0.145E-01																			
0.135E-01																			
0.125E-01																			
0.115E-01																			
0.105E-01																			
0.950E-02																			
0.800E-02																			
0.700E-02																			
0.600E-02																			
0.500E-02																			
0.400E-02																			
0.300E-02																			
0.200E-02																			
0.100E-02																			
0.																			
0.																			
1.2	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0



PLOT NUMBER
STS-3A STRESS WITH ENT=0.000 RECDV

TIME BASE
TOTAL TIME 100.0 HRS
RECOVERY AT 0.0 HRS
INCREMENT OF TIME 0.000 HRS

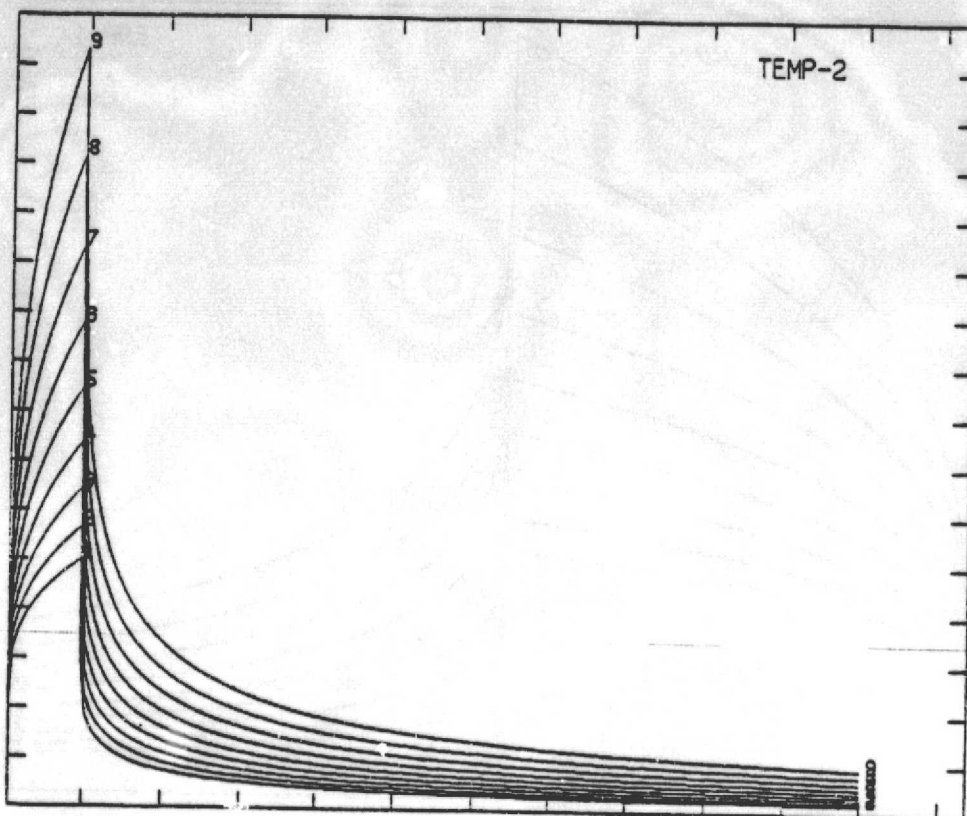
INPUT VARIABLES

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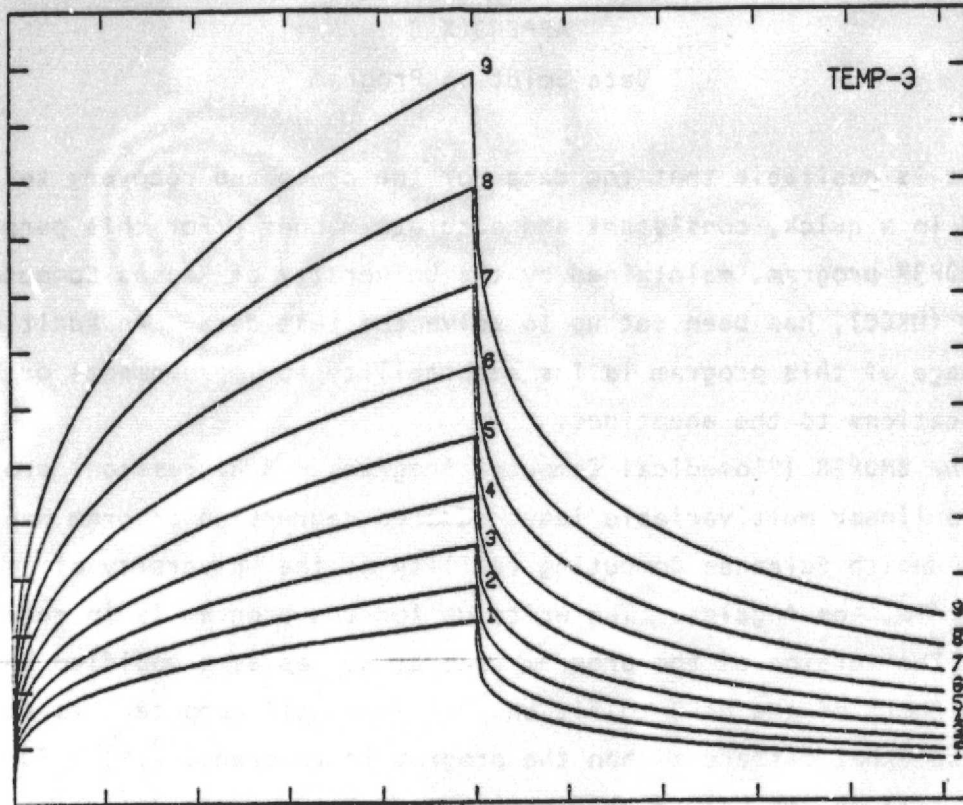


TEMP-2 TEMP VARIATION WITH HC

TIME LIST
TOTAL TIME 10.0 HRS
PERIODICITY AT 0.2 HRS
INCREMENT OF TIME 0.005 HRS

SPOT VARIABLES										
LINE NUMBER	SPRCD	CO	CI	CD	CT	EX	S	R	ENT	
1	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	2500	0.1000E+01	0.1000E+01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

0.316E+01
0.296E+01
0.275E+01
0.255E+01
0.235E+01
0.215E+01
0.195E+01
0.175E+01
0.155E+01
0.135E+01
0.115E+01
0.095E+01
0.075E+01
0.055E+01
0.035E+01
0.015E+01
0.005E+01



PLT NUMBER
TEMP-3 TO VIBRATION 411-40

TIME 3000
TOTAL TIME 2000.0 HRS
RECOVER 171000.0 HRS
INCURMENT IN TIME 11000.0 HRS

INPUT VARIABLES

LINE NUMBER	STEP (LINE)	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C37	C38	C39	C40	C41	C42	C43	C44	C45	C46	C47	C48	C49	C50	C51	C52	C53	C54	C55	C56	C57	C58	C59	C60	C61	C62	C63	C64	C65	C66	C67	C68	C69	C70	C71	C72	C73	C74	C75	C76	C77	C78	C79	C80	C81	C82	C83	C84	C85	C86	C87	C88	C89	C90	C91	C92	C93	C94	C95	C96	C97	C98	C99	C100	C101	C102	C103	C104	C105	C106	C107	C108	C109	C110	C111	C112	C113	C114	C115	C116	C117	C118	C119	C120	C121	C122	C123	C124	C125	C126	C127	C128	C129	C130	C131	C132	C133	C134	C135	C136	C137	C138	C139	C140	C141	C142	C143	C144	C145	C146	C147	C148	C149	C150	C151	C152	C153	C154	C155	C156	C157	C158	C159	C160	C161	C162	C163	C164	C165	C166	C167	C168	C169	C170	C171	C172	C173	C174	C175	C176	C177	C178	C179	C180	C181	C182	C183	C184	C185	C186	C187	C188	C189	C190	C191	C192	C193	C194	C195	C196	C197	C198	C199	C200	C201	C202	C203	C204	C205	C206	C207	C208	C209	C210	C211	C212	C213	C214	C215	C216	C217	C218	C219	C220	C221	C222	C223	C224	C225	C226	C227	C228	C229	C230	C231	C232	C233	C234	C235	C236	C237	C238	C239	C240	C241	C242	C243	C244	C245	C246	C247	C248	C249	C250	C251	C252	C253	C254	C255	C256	C257	C258	C259	C260	C261	C262	C263	C264	C265	C266	C267	C268	C269	C270	C271	C272	C273	C274	C275	C276	C277	C278	C279	C280	C281	C282	C283	C284	C285	C286	C287	C288	C289	C290	C291	C292	C293	C294	C295	C296	C297	C298	C299	C300	C301	C302	C303	C304	C305	C306	C307	C308	C309	C310	C311	C312	C313	C314	C315	C316	C317	C318	C319	C320	C321	C322	C323	C324	C325	C326	C327	C328	C329	C330	C331	C332	C333	C334	C335	C336	C337	C338	C339	C340	C341	C342	C343	C344	C345	C346	C347	C348	C349	C350	C351	C352	C353	C354	C355	C356	C357	C358	C359	C360	C361	C362	C363	C364	C365	C366	C367	C368	C369	C370	C371	C372	C373	C374	C375	C376	C377	C378	C379	C380	C381	C382	C383	C384	C385	C386	C387	C388	C389	C390	C391	C392	C393	C394	C395	C396	C397	C398	C399	C400	C401	C402	C403	C404	C405	C406	C407	C408	C409	C410	C411	C412	C413	C414	C415	C416	C417	C418	C419	C420	C421	C422	C423	C424	C425	C426	C427	C428	C429	C430	C431	C432	C433	C434	C435	C436	C437	C438	C439	C440	C441	C442	C443	C444	C445	C446	C447	C448	C449	C450	C451	C452	C453	C454	C455	C456	C457	C458	C459	C460	C461	C462	C463	C464	C465	C466	C467	C468	C469	C470	C471	C472	C473	C474	C475	C476	C477	C478	C479	C480	C481	C482	C483	C484	C485	C486	C487	C488	C489	C490	C491	C492	C493	C494	C495	C496	C497	C498	C499	C500	C501	C502	C503	C504	C505	C506	C507	C508	C509	C510	C511	C512	C513	C514	C515	C516	C517	C518	C519	C520	C521	C522	C523	C524	C525	C526	C527	C528	C529	C530	C531	C532	C533	C534	C535	C536	C537	C538	C539	C540	C541	C542	C543	C544	C545	C546	C547	C548	C549	C550	C551	C552	C553	C554	C555	C556	C557	C558	C559	C560	C561	C562	C563	C564	C565	C566	C567	C568	C569	C570	C571	C572	C573	C574	C575	C576	C577	C578	C579	C580	C581	C582	C583	C584	C585	C586	C587	C588	C589	C590	C591	C592	C593	C594	C595	C596	C597	C598	C599	C600	C601	C602	C603	C604	C605	C606	C607	C608	C609	C610	C611	C612	C613	C614	C615	C616	C617	C618	C619	C620	C621	C622	C623	C624	C625	C626	C627	C628	C629	C630	C631	C632	C633	C634	C635	C636	C637	C638	C639	C640	C641	C642	C643	C644	C645	C646	C647	C648	C649	C650	C651	C652	C653	C654	C655	C656	C657	C658	C659	C660	C661	C662	C663	C664	C665	C666	C667	C668	C669	C670	C671	C672	C673	C674	C675	C676	C677	C678	C679	C680	C681	C682	C683	C684	C685	C686	C687	C688	C689	C690	C691	C692	C693	C694	C695	C696	C697	C698	C699	C700	C701	C702	C703	C704	C705	C706	C707	C708	C709	C710	C711	C712	C713	C714	C715	C716	C717	C718	C719	C720	C721	C722	C723	C724	C725	C726	C727	C728	C729	C730	C731	C732	C733	C734	C735	C736	C737	C738	C739	C740	C741	C742	C743	C744	C745	C746	C747	C748	C749	C750	C751	C752	C753	C754	C755	C756	C757	C758	C759	C760	C761	C762	C763	C764	C765	C766	C767	C768	C769	C770	C771	C772	C773	C774	C775	C776	C777	C778	C779	C780	C781	C782	C783	C784	C785	C786	C787	C788	C789	C790	C791	C792	C793	C794	C795	C796	C797	C798	C799	C800	C801	C802	C803	C804	C805	C806	C807	C808	C809	C810	C811	C812	C813	C814	C815	C816	C817	C818	C819	C820	C821	C822	C823	C824	C825	C826	C827	C828	C829	C830	C831	C832	C833	C834	C835	C836	C837	C838	C839	C840	C841	C842	C843	C844	C845	C846	C847	C848	C849	C850	C851	C852	C853	C854	C855	C856	C857	C858	C859	C860	C861	C862	C863	C864	C865	C866	C867	C868	C869	C870	C871	C872	C873	C874	C875	C876	C877	C878	C879	C880	C881	C882	C883	C884	C885	C886	C887	C888	C889	C890	C891	C892	C893	C894	C895	C896	C897	C898	C899	C900	C901	C902	C903	C904	C905	C906	C907	C908	C909	C910	C911	C912	C913	C914	C915	C916	C917	C918	C919	C920	C921	C922	C923	C924	C925	C926	C927	C928	C929	C930	C931	C932	C933	C934	C935	C936	C937	C938	C939	C940	C941	C942	C943	C944	C945	C946	C947	C948	C949	C950	C951	C952	C953	C954	C955	C956	C957	C958	C959	C960	C961	C962	C963	C964	C965	C966	C967	C968	C969	C970	C971	C972	C973	C974	C975	C976	C977	C978	C979	C980	C981	C982	C983	C984	C985	C986	C987	C988	C989	C990	C991	C992	C993	C994	C995	C996	C997	C998	C999	C1000	C1001	C1002	C1003	C1004	C1005	C1006	C1007	C1008	C1009	C1010	C1011	C1012	C1013	C1014	C1015	C1016	C1017	C1018	C1019	C1020	C1021	C1022	C1023	C1024	C1025	C1026	C1027	C1028	C1029	C1030	C1031	C1032	C1033	C1034	C1035	C1036	C1037	C1038	C1039	C1040	C1041	C1042	C1043	C1044	C1045	C1046	C1047	C1048	C1049	C1050	C1051	C1052	C1053	C1054	C1055	C1056	C1057	C1058	C1059	C1060	C1061	C1062	C1063	C1064	C1065	C1066	C1067	C1068	C1069	C1070	C1071	C1072	C1073	C1074	C1075	C1076	C1077	C1078	C1079	C1080	C1081	C1082	C1083	C1084	C1085	C1086	C1087	C1088	C1089	C1090	C1091	C1092	C1093	C1094	C1095	C1096	C1097	C1098	C1099	C1100	C1101	C1102	C1103	C1104	C1105	C1106	C1107	C1108	C1109	C1110	C1111	C1112	C1113	C1114	C1115	C1116	C1117	C1118	C1119	C1120	C1121	C1122	C1123	C1124	C1125	C1126	C1127	C1128	C1129	C1130	C1131	C1132	C1133	C1134	C1135	C1136	C1137	C1138	C1139	C1140	C1141	C1142	C1143	C1144	C1145	C1146	C1147	C1148	C1149	C1150	C1151	C1152	C1153	C1154	C1155	C1156	C1157	C1158	C1159	C1160	C1161	C1162	C1163	C1164	C1165	C1166	C1167	C1168	C1169	C1170	C1171	C1172	C1173	C1174	C1175	C1176	C1177	C1178	C1179	C1180	C1181	C1182	C1183	C1184	C1185	C1186	C1187	C1188	C1189	C1190	C1191	C1192	C1193	C1194	C1195	C1196	C1197	C1198	C1199	C1200	C1201	C1202	C1203	C1204	C1205	C1206	C1207	C1208	C1209	C1210	C1211	C1212	C1213	C1214	C1215	C1216	C1217	C1218	C1219	C1220	C1221	C1222	C1223	C1224	C1225	C1226	C1227	C1228	C1229	C1230	C1231	C1232	C1233	C1234	C1235	C1236	C1237	C1238	C1239	C1240	C1241	C1242	C1243	C1244	C1245	C1246	C1247	C1248	C1249	C1250	C1251	C1252	C1253	C1254	C1255	C1256	C1257	C1258	C1259	C1260	C1261	C1262	C1263	C1264	C1265	C1266	C1267	C1268	C1269	C1270	C1271	C1272	C1273	C1274	C1275	C1276	C1277	C1278	C1279	C1280	C1281	C1282	C1283	C1284	C1285	C1286	C1287	C1288	C1289	C1290	C1291	C1292	C1293	C1294	C1295	C1296	C1297	C1298	C1299	C1300	C1301	C1302	C1303	C1304	C1305	C1306	C1307	C1308	C1309	C1310	C1311	C1312	C1313	C1314	C1315	C1316	C1317	C1318	C1319	C1320	C1321	C1322	C1323	C1324	C1325	C1326	C1327	C1328	C1329	C1330	C1331	C1332	C1333	C1334	C1335	C1336	C1337	C1338	C1339	C1340	C1341	C1342	C1343	C1344	C1345	C1346	C1347	C1348	C1349	C1350	C1351	C1352	C1353	C1354	C1355	C1356	C1357	C1358	C1359	C1360	C1361	C1362	C1363	C1364	C1365	C1366	C1367	C1368	C1369	C1370	C1371	C1372	C1373	C1374	C1375	C1376	C1377	C1378	C1379	C1380	C1381	C1382	C1383	C1384	C1385	C1386	C1387	C1388	C1389	C1390	C1391	C1392	C1393	C1394	C1395	C1396	C1397	C1398	C1399	C1400	C1401	C1402	C1403	C1404	C1405	C1406	C1407	C1408	C1409	C1410	C1411	C1412	C1413	C1414	C1415	C1416	C1417	C1418	C1419	C1420	C1421	C1422	C1423	C1424	C1425	C1426	C1427	C1428	C1429	C1430	C1431	C1432	C1433	C1434	C1435	C1436	C1437	C1438	C1439	C1440	C1441	C1442	C1443	C1444	C1445	C1446	C1447	C1448	C1449	C1450	C1451	C1452	C1453	C1454	C1455	C1456	C1457	C1458	C1459	C1460	C1461	C1
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APPENDIX B

Data Solution Program

It is desirable that the data for the creep and recovery test be solved in a quick, consistent and accurate manner. For this purpose the BMDP3R program, maintained by the University of Kansas Computation Center (UKCC), has been set up to solve the test data. An additional advantage of this program is its adaptability to improvements or modifications to the equations.

The BMDP3R (Biomedical Computer Programs - 3 Regression) program is a nonlinear multivariable least squares regression program written by the Health Sciences Computing facility at the University of California, Los Angeles. The write up for the program is in reference [12]. The version of the program used at KU has been modified by Judith Short of the UKCC to fit on KU's Honeywell computer, as such it is somewhat different than the program in reference [12]. Further information on the use of this program may be found in reference [13]. In reference [14] Rummler discussed the application of computer regression techniques to creep analysis.

Control Card Setup

The deck setup for the control cards is indicated in Figure B1. The \$IDENT card contains the user's identification information.

The \$ SELECT BMDP/TRANSF and \$ SELECT BMDP/P3RFUN access some of the BMDP files which are used to set up the user supplied function.

\$ INCODE indicates which keypunch was used to type the function section.

The user supplied function section contains the function which the computer is to fit and is discussed later.

\$ SELECT BMDP/BMDP3R accesses the main BMDP3R program files.

The \$ LIMITS card modifies the standard memory and lines of output limits of the program. The memory was increased because early problems with the program indicated that the standard limits were too low. The output was limited to prevent excessive output which can occur if the program has an error.

1	8	1
		6
\$	IDENT	project ID and name
\$	SELECT	BMDP/TRANSF
\$	SELECT	BMDP/P3RFUN
\$	INCODE	IBMF
		user supplied
		function section
\$	SELECT	BMDP/BMDP3R
\$	LIMITS	10,42K,,1600
\$	INCODE	IBMF
		program control
		information section
\$	DATA	08
		first data set
\$	ENDCOPY	08
\$	DATA	09
		second data set
\$	ENDCOPY	09
		.
		.
		.
		.
\$	ENDJOB	
	***EOF	

Figure B1. Control cards for BMDP3R program

The program control information (PCI) section contains the information necessary to run the program, this is discussed later.

The data which is to be stored in unit 08 is contained between \$ DATA 08 and \$ ENDCOPY 08. Additional data sets, if desired, would be stored similarly in unit 09, unit 10, etc.

The \$ ENDJOB and ***EOF end the program and follow the last \$ ENDCOPY card.

Note that separate decks are used for creep and recovery. The control cards are the same for each but the function and PCI sections are different.

Function Section

Figures B2 and B3 show the card setup for the function section of the creep and recovery programs. The purpose of this section is to calculate the function (equation) to be fitted and its partial derivatives with respect to the parameters.

This section is written in FORTRAN. No DIMENSION, END or last RETURN cards are needed as they are provided internally by the BMDP program.

In this section N is a number provided by the program control information which indicates which function is to be used. If there is only one function N is not necessary.

F is the dependent variable, or function, to be fitted. P(1), P(2), and P(3), and P(4) are the parameters of the function to be found. X(1) is the independent variable (TIME or RTIME in these programs), if desired more than one independent variable may be used. DF(1) is the partial derivative of F with respect to P(1), likewise DF(2) is $\partial F / \partial P(2)$ and so forth. RETURN indicates the end of the function.

In the creep function section the second function is written with the BTIME modification (see Appendix C). In the recovery function the second function is written with the Cend modification.

```

      IF(N.EQ.2) GO TO 2
      A =X(1)**P(3)
      F=P(1)+P(2)*A
      DF(1)=1
      DF(2)=A
      DF(3)=P(2)*ALOG(X(1)*A)
      RETURN
2  A = (X(1)+P(4))**P(3)
      F=P(1)+P(2)*A
      DF(1)=1
      DF(2)=A
      DF(3)=P(2)*ALOG(X(1)+P(4))*A
      DF(4)=P(2)*P(3)*(X(1)+P(4))**(P(3)-1)

```

Figure B2. Card setup of function section for creep

```

EXP=P(3)
C=1
AA=P(2)*X(1)
BB=1+AA
IF(N.EQ.2) GO TO 2
F=P(1)*(BB**EXP)-P(1)*(AA**EXP)
DF(1)=(BB**EXP)-AA**EXP
DF(2)=P(1)*EXP*X(1)*((BB*(EXP-1))- (AA*(EXP-1)))
DF(3)=P(1)*(ALOG(BB))*(BB**EXP)*C-P(1)*(ALOG(AA))*(AA**EXP)*C
RETURN
2 F=P(1)*(BB**EXP)-P(1)*(AA**EXP)+P(4)
DF(1)= BB**EXP-AA**EXP
DF(2)=P(1)*EXP*X(1)*((BB*(EXP-1))- (AA*(EXP-1)))
DF(3)=P(1)*(ALOG(BB))*(BB**EXP)*C-P(1)*(ALOG(AA))*(AA**EXP)*C
DF(4)=1

```

Figure B3. Card setup of function section for recovery

Program Control Information Section

Figures B4 and B5 show examples of the program control information for the creep and recovery programs. The purpose of this section is to provide the information necessary to run the program. Note that Figure B4 is for three different problems and B5 for two problems.

The PCI is set up in a paragraph-sentence format. Each paragraph begins in column 1 with a paragraph name. The end of a paragraph is indicated by a slash. The sentences following the paragraph name may begin in any column and must end with a period. There is only one sentence per line. For example in Figure B4 the first paragraph name is PROBLEM. This paragraph has only one sentence which is TITLE IS 'SOLUTION OF CREEP PARAMETERS'. The end of the paragraph is indicated by the slash in the next line.

The information on the setup of the PCI section is contained in reference [12]. The following information should be observed in addition to this.

UNIT IS 08 identifies 08 as the unit on which the data is contained. Note that the data unit's may be used in any order.

In VARIABLE NAMES ARE TIME, STRAIN./ the names must be in the order in which they are read from the data cards.

PLOT VARIABLE IS TIME ./ must be used in every problem in which a plot is desired, it does not carry over from one problem to the next.

ITERATION = 20 and HALVING = 5 are used to limit the amount of time the program uses if it does not converge.

The PARAMETER paragraph is very important, improper selection of the values contained in it will result in a less than optimum solution. It is important that the initial values of the parameters are close to the solution, preferably within 30% of the correct value. If they are too far off it may result in non-convergence, convergence on saddle points or nonimprovement (not pivoted upon) of one or more of the parameters. This is particularly important with the CPRIME parameter in the creep equation, see Figure B6. The parameter maximum and minimum should be reasonable tight. The program determines its improved values in part by how far it is from the maximum and minimum, if these are too wide it may have wide swings from guess to guess which will slow or prevent

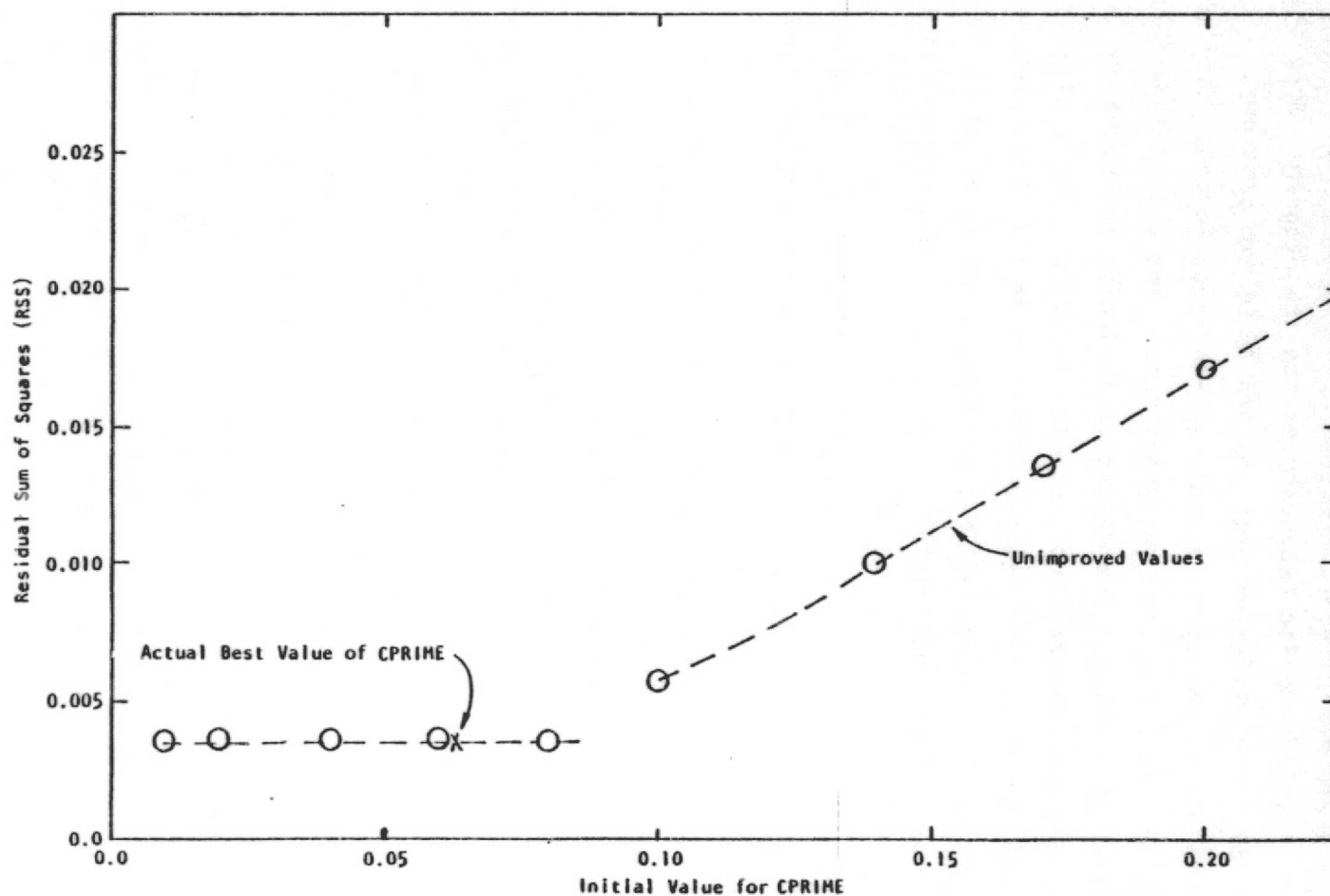


Figure B6. Residual sum of squares vs Initial guess of CPRIME for computer solution of Ti-3 creep data

```

PROBLEM      TITLE IS 'SOLUTION OF CREEP PARAMETERS' .
/
INPUT        VARIABLES ARE 2.
              UNIT IS 08
              FORMAT IS '(2F10.5)' .
/
VARIABLE NAMES ARE TIME, STRAIN .
/
PLOT          VARIABLE IS TIME ./
REGRESSION NUMBER IS 2.
              DEPENDENT IS STRAIN.
              PARAMETER IS 4.
              ITERATION = 20 .
              HALVING = 5 .
/
PARAMETER INITIALS ARE .1, .06, .33, 0.0 .
              MAXIMUM ARE 5., 10., 10., 0.0 .
              MINIMUM ARE 3*0.0001, 0.0 .
              NAMES ARE EO,CPRIME,N,BTIME .
/
END/
PROBLEM      TITLE IS 'ACCURACY TEST OF BMDP3R PROGRAM' ./
PLOT          VARIABLE IS TIME ./
PARAMETER INITIALS ARE .1, .10, .33, 0.0 ./
END/
PROBLEM      TITLE IS 'ACCURACY TEST OF BMDP3R PROGRAM' ./
INPUT        UNIT IS 09 ./
PLOT          VARIABLE IS TIME ./
END/
FINISH/

```

Figure B4. Program control information setup for creep

```

PROBLEM  TITLE IS 'CREEP VARIATION TEST ANALYSIS' ./
INPUT    VARIABLES ARE 2.
          UNIT IS 08.
          FORMAT IS '(2F10.5)' ./
VARIABLE NAMES ARE RTIME, STRAIN ./
PLOT     VARIABLE IS RTIME ./
REGRESSION NUMBER IS 2 .
          DEPENDENT IS STRAIN.
          PARAMETER IS 4.
          ITERATION IS 20.
          HALVING IS 5.

```

```

/
PARAMETER INITIALS ARE 0.7, 0.001, 0.25, 0.0 .
          MAXIMUM ARE 3*5., 0.0 .
          MINIMUM ARE 3*0.000001, 0.0
          NAMES ARE CO,ENT,N,CEND. /

```

END/

```

PROBLEM  TITLE IS ' BMDP3R RECOVERY TEST' ./
PLOT     VARIABLE IS RTIME./
PARAMETER INITIALS ARE 0.7, 0.5, 0.5329, 0.2 .
          MAXIMUM ARE 2*5., 0.5329, 0.9 .
          MINIMUM ARE 2*0.00001, 0.5329, 0.00001 ./

```

END/

FINISH/

Figure B5. Program control information setup for recovery

convergence. If it is desired, any of the parameters may be fixed at any point as was done with BTIME in the creep program.

In the PCI section ARE, IS and = are interchangeable.

When more than one problem is to be run each problem must begin with a PROBLEM card and end with an END/ card. All other information except the PLOT paragraph is carried over to the next problem. To change something just add the necessary card(s). The FINISH/ card follows the END/ card of the last problem.

Analysis of Output

Figures B7 and B8 are the output of the first creep and recovery problems in Figures B4 and B5.

Referring to the notes on Figure B7, 1 is the title heading for the BMDP3R program.

2 is a reprint of the program control information cards used for the problem.

Section 3 is the general program information that is being used.

4 is the number of data points used.

5 is the maximum and minimum for the parameters.

6 is the sum of the squares of the residuals (RSS) from the following equation

$$RSS = \sum_{i=1}^n [Y_i - f(x_i, p)]^2$$

where y_i are the data values and $f(x_i, p)$ are the calculated values. This is an indication of the quality of fit achieved. The bottom line represents the final results.

The values of the parameters of the equation are shown in section 7. The bottom line represents the computers best fit.

Section 8 contains the information on the standard deviation (SD) of the parameters. This is also an indication of the quality of fit. If one of the parameters is not improved (not pivoted on), lies on a boundary or is fixed its standard deviation is 0.0.

In section 9 are the results for each data point (case number). The predicted strain is the value calculated from the best guess in 7.

IN THIS VERSION OF BMDP3R

- IF THE CONSTRAINT OR TRANSFORMATION SUBROUTINES, CON OR TRANS, ARE USED, FUNCTIONS AND DERIVATIVES MUST BE SPECIFIED IN SUBROUTINE FORTHE BUILT-IN FUNCTIONS F(1) TO F(5) CANNOT BE USED WITH CONSTRAINT OR TRANSFORM LOGICAL.
- IF BUILT-IN FUNCTION F(1) IS USED, THE NUMBER OF PARAMETERS SPECIFIED MUST BE AT LEAST 4.

UNIVERSITY OF KANSAS COMBUSTION CENTER

VERSION 2.1A 16/07/77

PROGRAM CONTROL INFORMATION

PROBLEM TITLE IS 'SOLUTION OF CREEP PARAMETERS'

INPUT VARIABLES ARE 2.
UNIT IS 18
FORMAT IS '12E10.51'

VARIABLE NAMES ARE TIME, STRAIN

PLOT VARIABLE IS TIME
REGRESSION NUMBER IS 2.
INCREMENT IS STRAIN.
PARAMETER IS 4.
ITERATION IS 20.
HALVING IS 5.

PARAMETER INITIALS ARE .1, .05, .15, 0.0
MAXIMUM ARE 5., 10., 10., 5.0
MINIMUM ARE 3*0.0001, 0.0
NAMES ARE EQ, CPRINT, N, TIME

END/

PROBLEM TITLE SOLUTION OF CREEP PARAMETERS

NUMBER OF VARIABLES TO READ IN. 2
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. 0
TOTAL NUMBER OF VARIABLES 2
NUMBER OF CASES TO READ IN. 100000
CASE LABELING VARIABLES
LIMITS AND MISSING VALUE CHECKED BEFORE TRANSFORMATIONS
INPUT UNIT NUMBER 8
REWIND INPUT UNIT PRIOR TO READING. YES

INPUT FORMAT
(12E10.51)

VARIABLES TO BE USED
1 TIME 2 STRAIN

VARIABLES TO BE PLOTTED
1 TIME

Figure B7. Output from BMDP3R creep program for Ti-3 data

PLOT OF PREDICTED VALUES VERSUS RESIDUALS . . .
PROFIT PLOT OF RESIDUALS . . .

10
10

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Figure B7. Cont'd.

ASYMPTOTIC CORRELATION MATRIX OF THE PARAMETERS

	EC	CPIME	N	PAM	SD
	1	2	3	4	5
EC	1				
CPIME	2	1.0000			
N	3	-0.9321	1.0000		
PAM	4	0.9321	-0.9321	1.0000	
SD	5	0.15734E-11	0.70771E-02	0.21208E-01	1.0000

ASYMPTOTIC STANDARD DEVIATIONS OF THE PARAMETERS ASSUMING 2N DEGREES OF FREEDOM
WITH PARAMETER MAXIMUMS AND MINIMUMS HOLDING 1 PARAMETER(S) FIXED

EC CPIME N PAM SD

IF A PARAMETER IS REDUNDANT (NOT PLANTED OR LIES ON A BOUNDARY), IT IS ASSIGNED A STANDARD DEVIATION OF 0.0.
THE CORRESPONDING ROW AND COLUMN OF THE CORRELATION MATRIX ARE OMITTED.

Figure B7. Cont'd.

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CASE NO. NAME	PREDICTED STRAIN	STD DEV OF PRED VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1	2.232141	0.00887	2.206600	-0.025541	1.143033
2	2.415534	0.00515	2.337200	-0.078334	5.143033
3	2.369814	0.00296	2.398600	0.028786	9.143033
4	2.413668	0.00348	2.430300	0.016632	13.143033
5	2.451634	0.00335	2.450100	-0.001534	17.143000
6	2.485579	0.00322	2.471300	-0.014279	21.143000
7	2.516661	0.00318	2.503100	-0.013561	25.143033
8	2.545596	0.00314	2.539100	-0.006496	29.143000
9	2.572552	0.00299	2.563100	-0.009452	33.143033
10	2.598112	0.00303	2.590600	-0.007512	37.143000
11	2.622415	0.00295	2.616300	-0.006115	41.143033
12	2.645637	0.00246	2.642800	-0.002837	45.143033
13	2.667916	0.00277	2.673200	0.005284	49.143033
14	2.689363	0.00267	2.695000	0.005637	53.143033
15	2.710068	0.00257	2.714900	0.004832	57.143033
16	2.730106	0.00249	2.742300	0.012194	61.143033
17	2.749541	0.00241	2.751500	0.001959	65.143000
18	2.768426	0.00236	2.767000	-0.001426	69.143033
19	2.786807	0.00234	2.783300	-0.003507	73.143033
20	2.804724	0.00235	2.804500	-0.000224	77.143000
21	2.822213	0.00233	2.818600	-0.003613	81.143033
22	2.839303	0.00247	2.829900	-0.009403	85.143033
23	2.856021	0.00259	2.852500	-0.003521	89.143033
24	2.872394	0.00274	2.868700	-0.003694	93.143033
25	2.888444	0.00292	2.879300	-0.009144	97.143033
26	2.904181	0.00312	2.913900	0.009719	101.143000
27	2.919634	0.00335	2.918100	-0.001534	105.143033
28	2.934415	0.00360	2.943500	0.009085	109.143033
29	2.949737	0.00387	2.956600	0.006863	113.143033
30	2.964416	0.00415	2.964700	0.000284	117.143000
31	2.971667	0.00430	2.978800	0.007133	119.143033

SERIAL CORRELATION OF RESIDUALS=SUM(R(I)*R(I-1))/SQRT(SUM(R(I)**2)*SUM(R(I-1)**2))

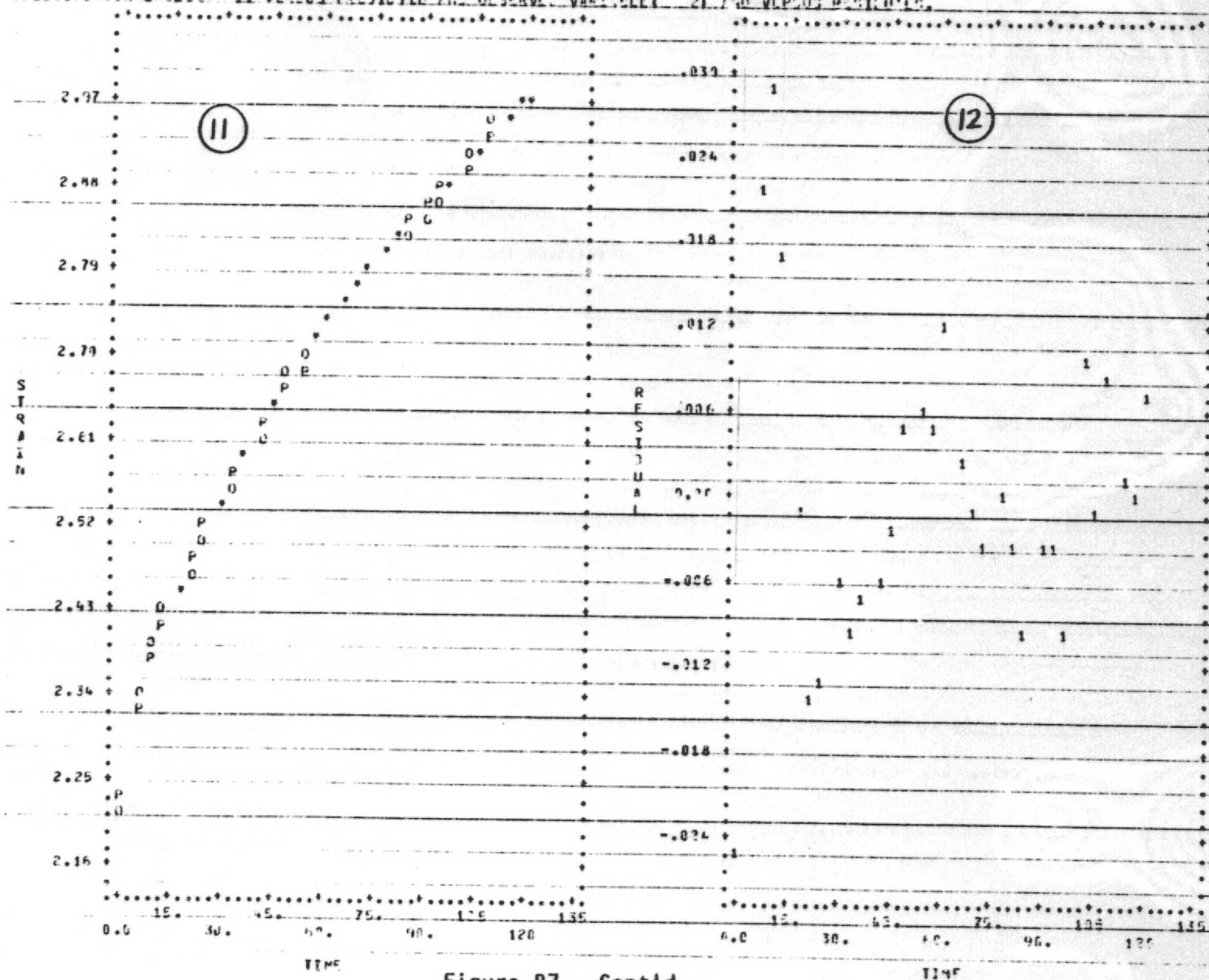
ALL SUMS ARE FOR I=2, NUMBER OF CASES

SERIAL CORRELATION
0.36498

RESIDUALS ORDERED ON
CASE NUMBER

10

Figure B7. Cont'd.



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PROPR - NON-LINEAR REGRESSION
HEALTH SCIENCES COMPUTING FACILITY
UNIVERSITY OF CALIFORNIA, LOS ANGELES

PROGRAM REVISED FEBRUARY 7, 1975
JANUARY DATE -- 1975

IN THIS VERSION OF PROPR

- IF THE CONSTRAINT OR TRANSFORMATION SUBROUTINES, CON OR TRANS, ARE USED, FUNCTIONS AND DERIVATIVES MUST BE SPECIFIED IN SUBROUTINE FUNCTIONE (BUILT-IN FUNCTIONS F(1) TO F(5) CANNOT BE USED WITH CONSTRAINTS OR TRANSFORMATIONS).
- IF BUILT-IN FUNCTION F(1) IS USED, THE NUMBER OF PARAMETERS SPECIFIED MUST BE AT LEAST 2.

UNIVERSITY OF KANSAS COMPUTATION CENTER

VERSION 2.1A 06/27/77

PROGRAM CONTROL INFORMATION

PROBLEM TITLE IS 'CREEP VARIATION TEST ANALYSIS'.

INPUT VARIABLES ARE 2.

UNIT IS CO.

FORMAT IS '(2F10.5)'.

VARIABLE NAMES ARE RTIME, STRAIN.

/

PLOT VARIABLE IS RTIME.

REGRESSION NUMBER IS 2.

DEPENDENT IS STRAIN.

PARAMETER IS 4.

ITERATION IS 20.

HALVING IS 5.

/

PARAMETER INITIALS ARE 0.7, 0.001, 0.25, 0.0.

MAXIMUM ARE 3.5, 0.0

MINIMUM ARE 3.0, 0.00001, 0.0

NAMES ARE COEFF, ACCEND.

END/

PROBLEM TITLE CREEP VARIATION TEST ANALYSIS

NUMBER OF VARIABLES TO READ IN. 2

NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. 0

TOTAL NUMBER OF VARIABLES 2

NUMBER OF CASES TO READ IN. 100000

CASE LABELING VARIABLES

LIMITS AND MISSING VALUE CHECKED BEFORE TRANSFORMATIONS

INPUT UNIT NUMBER 6

RECORD INPUT UNIT PRIOR TO READING. . DATA. . . YES

INPUT FORMAT

(2F10.5)

VARIABLES TO BE USED

1 RTIME 2 STRAIN

VARIABLES TO BE PLOTTED

1 RTIME

PLOT OF PREDICTED VALUES VERSUS RESIDUALS BY

PRINT PLOT OF RESIDUALS. NO

Figure B8. Output from BMDP3R recovery program for Ti-3 data

(b) (7)(C), (b) (7)(D)

COMPRESSION NUMBER	2
DEPENDENT VARIABLE	STRAIN
WEIGHTING VARIABLE	
NUMBER OF PARAMETERS	4
NUMBER OF CONSTRAINTS	0
TOLERANCE FOR PIVOTING	0.0000
TOLERANCE FOR CONVERGENCE	0.00001
MAXIMUM NUMBER OF ITERATIONS	20
MAXIMUM NUMBER OF INCREMENT HALVINGS	5

NUMBER OF CASES READ.....36

VALUE	STANDARD	MINIMUM	MAXIMUM
NO. 447	DEVIATION		
1. TIME	3.361155	0.316694	1.936500
2. STRAIN	2.522111	0.466440	2.354133

PARAMETER TAX11A	5.00000000	5.00000000	5.00000000	3.
PARAMETER TAX12A	0.00000000	0.00000000	0.00000000	3.

ITERATION NUMBER	INCREMENT HALVINGS	RESIDUAL SUM OF SQUARES	CO	ENL	N	CEB
0	0	0.255506	0.700000	0.001000	0.255000	0.
1	2	0.224013	0.762339	0.001000	0.187500	0.
2	3	0.206520	0.805624	0.001000	0.166263	0.
3	2	0.195824	0.805624	0.004250	0.240753	0.
4	0	0.062316	1.043522	0.017635	0.152374	0.
5	1	0.114285	1.043522	0.036066	0.239022	0.
6	3	0.000785	1.051320	0.034926	0.235137	0.
7	0	0.006649	1.053766	0.052460	0.236663	0.
8	0	0.000648	1.053492	0.052533	0.236357	0.
9	0	0.000648	1.053484	0.052585	0.236363	0.
10	0	0.000648	1.053484	0.052585	0.236363	0.
11	0	0.000648	1.053484	0.052585	0.236363	0.
12	0	0.000648	1.053484	0.052585	0.236363	0.
13	0	0.000648	1.053484	0.052585	0.236363	0.

ITERATION 13 HAS THE SMALLEST RESIDUAL SUM OF SQUARES(SUBJECT TO CONSTRAINTS, IF ANY).
91 161175 CALCULATIONS ARE BASED ON THE RESULTS OF THIS ITERATION.

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Figure B8. Cont'd.

ASYMPTOTIC CORRELATION MATRIX OF THE PARAMETERS

	CO	ENT	N	ENB	CO
	1	2	3		59738366
CO	1	1.0000			
ENT	2	-0.9632	1.0000		
N	3	-0.9917	0.9893	1.0000	
ENB	008363	0.	0.	0.	0.

ASYMPTOTIC STANDARD DEVIATIONS OF THE PARAMETERS ASSUMING 33 DEGREES OF FREEDOM
 WITH PARAMETER MAXIMUMS AND MINIMUMS HOLDING 1 PARAMETER(S) FIXED

CO ENT N ENB

IF A PARAMETER IS REDUNDANT (NOT PIVOTED ON) OR LIES ON A BOUNDARY, IT IS ASSIGNED A STANDARD DEVIATION OF 0.0.
 THE CORRESPONDING ROW AND COLUMN OF THE CORRELATION MATRIX ARE OMITTED.

Figure B8. Cont'd

CASE NO. NAME	PREDICTED STRAIN	STD DIV OF PRED. VALUE	OBSERVED STRAIN	RESIDUAL	RTIME
1	0.354301	0.00316	0.854002	-0.000801	0.016674
2	0.312522	0.00265	0.816700	-0.002329	0.033332
3	0.276121	0.00160	0.791200	-0.004221	0.050283
4	0.278144	0.00140	0.778600	0.000456	0.066778
5	0.253371	0.00131	0.764400	0.001029	0.083672
6	0.250738	0.00128	0.754500	0.003762	0.100167
7	0.239650	0.00122	0.746100	0.006450	0.115860
8	0.221742	0.00129	0.724200	0.003458	0.150250
9	0.204626	0.00130	0.705200	0.001216	0.183632
10	0.673955	0.00130	0.631100	0.002855	0.250420
11	0.653109	0.00127	0.649400	-0.008709	0.312192
12	0.640477	0.00122	0.640200	-0.000277	0.383970
13	0.625158	0.00116	0.631000	0.005842	0.450752
14	0.611574	0.00110	0.614000	0.002426	0.517530
15	0.522369	0.00104	0.606300	0.006952	0.586310
16	0.588217	0.00099	0.585100	-0.003117	0.651090
17	0.577966	0.00095	0.571000	-0.006966	0.712960
18	0.563515	0.00091	0.572400	0.008885	0.784640
19	0.557591	0.00088	0.553300	-0.004291	0.851420
20	0.551428	0.00087	0.543400	-0.008028	0.918200
21	0.543656	0.00086	0.539300	-0.004356	0.986220
22	0.536322	0.00086	0.530300	-0.005522	1.051700
23	0.529365	0.00088	0.520200	-0.009165	1.113500
24	0.522758	0.00090	0.518800	-0.003953	1.185300
25	0.516453	0.00092	0.514600	-0.001853	1.252100
26	0.510435	0.00096	0.511800	0.001364	1.318900
27	0.504685	0.00099	0.503200	0.001485	1.385600
28	0.497162	0.00103	0.500400	0.001238	1.452400
29	0.493355	0.00104	0.501100	0.007745	1.519200
30	0.483749	0.00112	0.489400	0.005651	1.586000
31	0.483829	0.00117	0.482100	-0.001729	1.652800
32	0.477084	0.00121	0.481400	0.004316	1.719500
33	0.474501	0.00126	0.476600	0.002100	1.786300
34	0.470064	0.00131	0.467400	-0.002664	1.853100
35	0.465763	0.00136	0.470900	0.005137	1.919900
36	0.461609	0.00140	0.464400	0.002791	1.986600

SERIAL CORRELATION OF RESIDUALS = $\frac{\sum(R(I) \cdot R(I-1))}{\sqrt{(\sum(R(I)^2) \cdot \sum(R(I-1)^2))}}$

ALL SU4S ARE FOR I=2, NUMBER OF CASES

SERIAL CORRELATION OF RESIDUALS ORDERED ON CASE NUMBER
0.51042

Figure B8. Cont'd.

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Figure 88. Cont'd

The residual is the difference between the predicted and observed (data) strains.

10 is the serial correlation (SC). This number varies from one to negative one and is an indication of the quality of fit, closer to zero indicating a better fit.

11 is a plot of the predicted and observed values of strain vs. time. P indicates predicted strain, O indicates observed and an * indicates an overlap. Ideally the plot would be all *.

12 is a plot of the values of the residuals of each point vs. time. Ideally this should be a random scatter indicating the random experimental error of the test data. The amount of clumping or trends on this plot are an indication of the quality of fit.

Quality of Fit and Accuracy of the Program

The quality of fit and trend toward improvement is a function of the number of data points. At least 25 data points should be used and preferably more. Increasing the number of data points seems to increase the RSS and SC, however it provides a decrease (improvement) in the standard deviation values. It also seems to help if the data points are evenly distributed rather than weighted toward one end of the curve. Increasing the number of data points also seems to help the program converge when poor initial values are used.

The major indication of a valid fit is obtained from the standard deviation of the parameters. If the SD of any of the unfixed parameters is 0.0 this indicates that the program does not feel that this parameter is necessary in the equation and that changing (improving) it would have no effect on the results. With either the creep or recovery equations this indicates that either the curve is very flat or that an optimum fit was not achieved. This is usually caused by a poor initial guess for the unimproved parameter. To find a better initial value rerun the program with a slightly larger or smaller initial value for the unimproved parameter, this should result in a different RSS value. A comparison of this RSS with the previous one will indicate the direction the initial guess should be improved. This type of error is illustrated in Figure B6 where the higher values of the RSS occurred with CPRIME

was not improved, however when the initial guess for CPRIME was close enough the program improved its value, resulting in a lower RSS. If any of the non-fixed parameters are not improved the SD values calculated by the program are much too low.

Sometimes the program will find a saddle point or non-optimum solution if the initial values are too far off. This is sometimes difficult to detect, however it should be suspected when results are not consistent with other results of similar data. If this is the case, change the initial values.

It is important that the maximum and minimum values of the parameters are possible in the function section equations. This is especially true with BTIME in the creep equation. If it becomes larger than any of the early data times the resultant adjusted time is less than zero. This causes several errors in the function equations which will result in a very large amount of output because the function section is called many times by the program.

It is difficult to define an exact point at which a good fit of the equation to the data occurs. In general, observing the plot graph indicates whether or not the curves fit each other. The RSS gives an indication of the fit, a RSS of less than .2% of the average strain value generally indicates a good fit. Note that the standard deviation for the strain is given by

$$\sigma_s = \sqrt{\frac{RSS}{df}}$$

where df is the degrees of freedom indicated in section 8. The SD's of the parameters are variable but are usually below 10% for a good fit. The serial correlation value also indicates the quality of fit, however it is also variable. Generally below .4 is a good fit, however higher values have sometimes given a good fit. The residual plot with a good random scatter indicates that the equation fit the curve to the best of its ability and that a poor fit was caused by the scatter of the data. If the residual plot indicates a trend (the points seem to follow a line), this indicates that either the optimum solution was not reached or that the equation was inherently incapable of fitting the data.

APPENDIX C Effect of Loading Rate

The amount of creep that occurs in the creep test during the period when the load is being applied can be approximated as follows:

For constant temperature, assume that creep follows the power law equation

$$\epsilon = Ct^n \quad (C1)$$

where

$$C = C_0\sigma$$

where C_0 is a constant, σ is the stress, n is the exponent, t is the time, and ϵ is the amount of creep strain, not including elastic strain. C_0 and n are assumed to be independent of stress. Although this is not strictly true, for the purposes of this approximation the error will probably not be significant.

The loading period begins at $t=0$ and continues to $t=t_1$ and from $\sigma=0$ to $\sigma=\sigma_0$, the loading rate is assumed to be constant. Thus C for time less than t_1 is

$$C = C_0\sigma = C_0\sigma_0 \frac{t}{t_1} \quad t \leq t_1 \quad (C3)$$

The loading rate can be viewed as a series of finite increments in step loading, as indicated on Figure C1, where an incremental load, $\Delta\sigma$, is applied for a time Δt . For k increments the load step would be

$$\Delta\sigma = \frac{\sigma_0}{k} \quad (C4)$$

and the time increment

$$\Delta t = \frac{t_1}{k} \quad (C5)$$

As indicated on Figure C2 the amount of creep strain during the first increment, ϵ_1 , would be

$$\epsilon_1 = \Delta\sigma C_0 \Delta t^n \quad (C6)$$

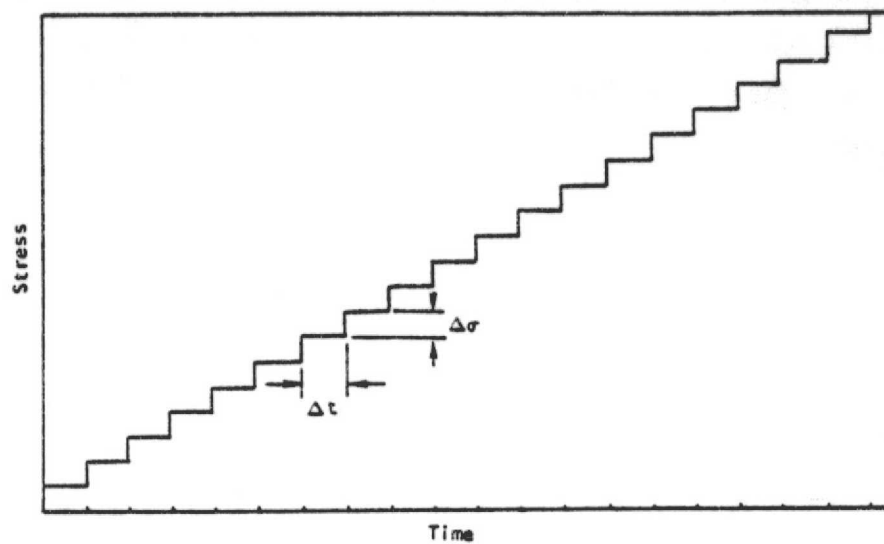


Figure C1. Incremental loading, stress vs time

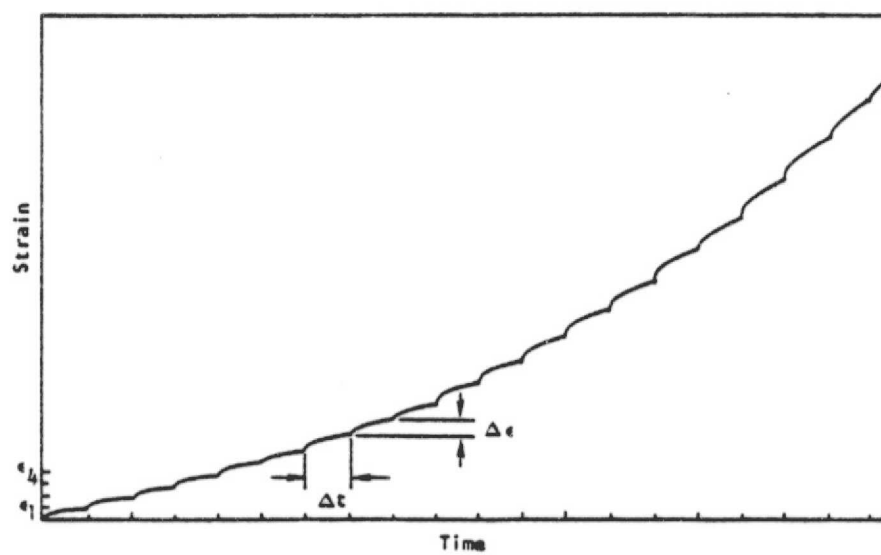


Figure C2. Creep strain for incremental loading

This is equal to the strain at the beginning of the second increment of strain. The second increment of strain can be viewed as a new creep curve related to the previous creep only by the amount of strain, ϵ_1 . The equation from the second creep curve for the strain, ϵ_1 , is

$$\epsilon_1 = 2\Delta\sigma C_0 (t_d)^n \quad (C7)$$

where $2\Delta\sigma$ is the stress and t_d is a time adjustment factor which represents the amount of time necessary for equation (C7) to reach ϵ_1 . Time t_d is less than Δt .

Solving equations (C6) and (C7) for t_d gives

$$t_d = (1/2)^{1/n} \Delta t \quad (C8)$$

Using this in equation (C7), ϵ_1 , becomes

$$\epsilon_1 = 2\Delta\sigma C_0 [(1/2)^{1/n} \Delta t]^n \quad (C9)$$

and at the end of the second increment of time the strain, ϵ_2 , is

$$\begin{aligned} \epsilon_2 &= 2\Delta\sigma C_0 [\Delta t + (1/2)^{1/n} \Delta t]^n \\ \epsilon_2 &= 2\Delta\sigma C_0 \Delta t^n [1 + (1/2)^{1/n}]^n \end{aligned} \quad (C10)$$

In a similar manner the equation for ϵ_2 in the next increment of strain is

$$\epsilon_2 = 3\Delta\sigma C_0 (t_d)^n \quad (C11)$$

where t_d is now equal to

$$t_d = (2/3)^{1/n} [1 + (1/2)^{1/n}] \Delta t \quad (C12)$$

and

$$\epsilon_3 = 3\Delta\sigma C_0 \Delta t^n [1 + (2/3)^{1/n} (1 + 1/2)^{1/n}]^n \quad (C13)$$

similarly

$$\epsilon_4 = 4\Delta\sigma C_0 \Delta t^n [1 + (3/4)^{1/n} (1 + 2/3)^{1/n} (1 + 1/2)^{1/n}]^n \quad (C14)$$

For k increments this becomes

$$\epsilon_k = k \Delta \sigma C_0 \Delta t^n \left[1 + \left(\frac{k-1}{k} \right)^{1/n} \left(1 + \left(\frac{k-2}{k-1} \right)^{1/n} \left(1 + \dots (2/3)^{1/n} \right. \right. \right. \\ \left. \left. \left. (1 + 1/2)^{1/n} \dots \right) \right] \right]^n \quad (C15)$$

Including the expressions for time and stress from equations (C4) and (C5) this becomes

$$\epsilon_k = \sigma_0 C_0 t_1^n \frac{1}{k^n} [\dots]^n \quad (C16)$$

or

$$\epsilon_k = \sigma_0 C_0 t_1^n \times f(n, k) \quad (C17)$$

where

$$f(n, k) = \frac{1}{k^n} \left[1 + \left(\frac{k-1}{k} \right)^{1/n} \left(1 + \left(\frac{k-2}{k-1} \right)^{1/n} \right. \right. \\ \left. \left. (\dots (1 + 1/2)^{1/n}) \right) \right]^n \quad (C18)$$

The values for this function for k=100 are plotted on Figure C3. The equation for the curve from t=0 to t=t₁ is

$$\epsilon = \sigma_0 \left(\frac{t}{t_1} \right) C_0 \left(t_1 \times \frac{t}{t_1} \right)^n f(n, k) \quad t \leq t_1 \quad (C19)$$

The equations for the curves after loading is finished (t greater than t₁) can be calculated from the fact that the strain rate at t=t₁, $\dot{\epsilon}(t_1)$, for (C19) will be the same as the $\dot{\epsilon}$ immediately after t₁ when the stress is constant. Thus the strain rate of (C19) at t₁ is

$$\dot{\epsilon} = \frac{d\epsilon}{dt} = (n+1) \frac{\sigma_0 C_0}{t_1} (t_1)^n f(n, k) \quad (C20)$$

the strain rate of equation (C1) at t=t₁ is

$$\dot{\epsilon} = n C t_b^{n-1} \quad (C21)$$

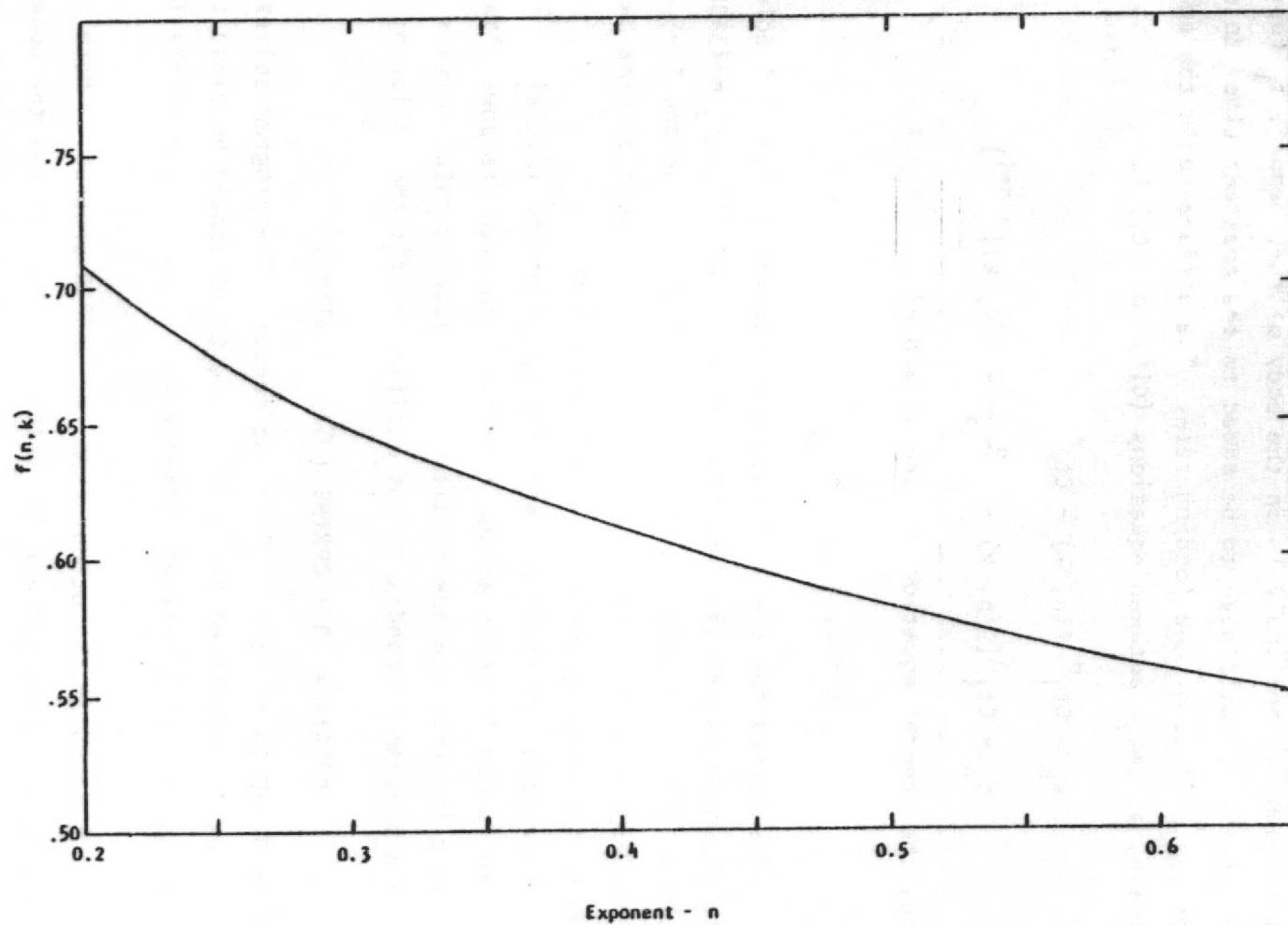


Figure C3. Plot of $f(n, k)$ from equation (C18) vs n for $k = 100$

where t_b is an adjusted time. Solving (C20) and (C21) for t_b gives

$$t_b = \left(\frac{(n+1)}{n} f(n, k) \right)^{1/n-1} t_1 \quad (C22)$$

If the end of the loading period were taken as the beginning of creep, as was done in the analysis in the body of this report, t_b represents the time that would have to be added to the apparent time to correct for the effects of the loading rate. The difference in the amount of strain, at $t=t_1$, between equations (C19) and (C1) is

$$\begin{aligned} \epsilon_b &= C t_1^n f(n, k) - C t_b^n \\ \epsilon_b &= C t_1^n \left[f(n, k) - \left(\frac{(n+1)}{n} f(n, k) \right)^{n/n-1} \right] \end{aligned} \quad (C23)$$

Thus the general equation for the strain after $t-t_1$ is

$$\epsilon = C(t - t_1 + t_b)^n + \epsilon_b \quad (C24)$$

The curves for the Ti-3 data with several different loading rates are shown on Figure C4. For the Ti-3 data $n=0.5329$, $\sigma_0 = 23400$, $C_0 = 2.70 \times 10^{-9}$, $t_1 = .225$ min, and $f(n, k)=0.5738$. For the Ti-3 data $t_b=0.0769$ min., this represents the apparent amount of time before the end of the loading period at which creep began.

Garofalo indicates in reference [15] that the initial creep rate at $t=0$ is not infinity as would be the case with the power law. To account for this and the results of the loading rate analysis the BMDP3R program (Appendix B) was modified to fit the following equation

$$\text{STRAIN} = E0 + \text{CPRIME} (\text{TIME} + \text{BTIME})^N$$

where BTIME is the time adjustment factor. The program solves for BTIME as a function of the data, where BTIME should be close to t_b . Note that the Ti-3 data was taken with $t=0$ at the end of the loading period.

Figure C5 is the output from the BMDP3R program. Note that the program solved for a BTIME value of 4.9 which was the upper limit allowed. This is not even close to the 0.0769 value expected from the previous calculations. This difference in results

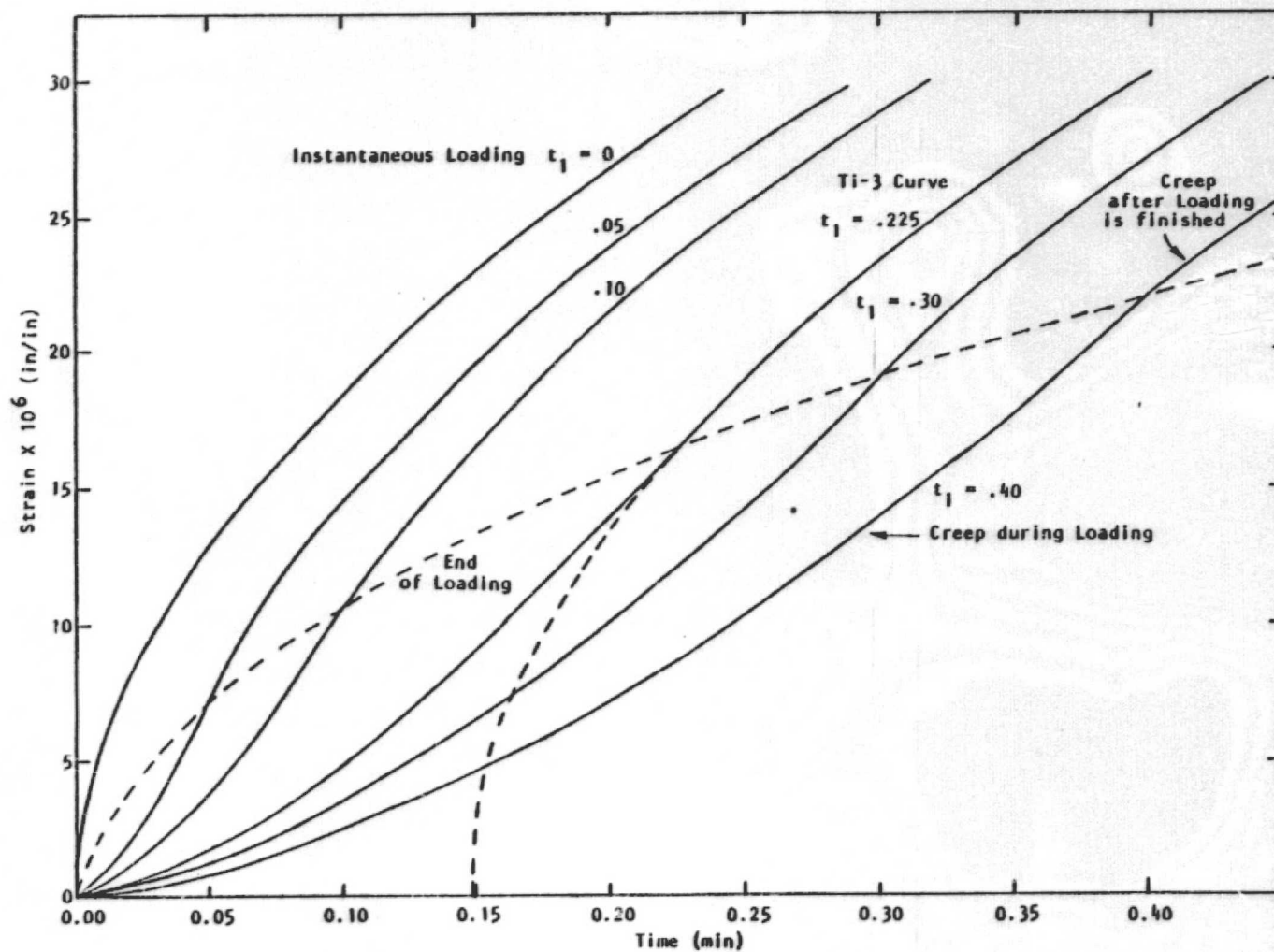


Figure C4. Creep strain vs time for different loading rates using Ti-3 test conditions

may have been due in part to inconsistencies in the Ti-3 data. However, in view of the large differences and to avoid any further complexities in future analyses the BTIME modification has not been used in any of the later solutions of the data. The expected effect of this modification on the parameters of the TC theory would be less than 2%.

Figure C5. Sample output from BTIME modification to creep equation using Ti-3 data

ASYMPTOTIC CORRELATION MATRIX OF THE PARAMETERS

	EQ	CPRIME	PHM	QD	PHM	QD
	1	2	54738368	59731368		

EQ	1	1.0000				
CPRIME	2	-0.9564	1.0000			
PHM	008368	0.	0.	0.		
PHM	008368	0.0119	-0.0007	0.	0.	

ASYMPTOTIC STANDARD DEVIATIONS OF THE PARAMETERS ASSUMING 24 DEGREES OF FREEDOM

WITH PARAMETER MAXIMUMS AND MINIMUMS HOLDING 1 PARAMETER(S) FIXED

	EQ	CPRIME	K	BTIM
	0.49350E-02	0.51843E-03	0.	0.

IF A PARAMETER IS REDUNDANT (NOT PIVOTED ON) OR LIES ON A BOUNDARY, IT IS ASSIGNED A STANDARD DEVIATION OF 0.0.
THE CORRESPONDING ROW AND COLUMN OF THE CORRELATION MATRIX ARE OMITTED.

Figure C5. Cont'd.

CASE NO.	CASE NAME	PREDICTED STRAIN	STD DEV OF PRED. VALUE	OBSERVED STRAIN	RESIDUAL	TIME
1		2.336987	0.003328	2.337201	0.000214	5.143000
2		2.381227	0.00257	2.390601	0.017374	9.143000
3		2.419867	0.002271	2.430301	0.010434	13.143000
4		2.454669	0.00249	2.450101	-0.004568	17.143000
5		2.486623	0.00229	2.471301	-0.015322	21.143000
6		2.516355	0.00211	2.503101	-0.013254	25.143000
7		2.544289	0.00126	2.539101	-0.005188	29.143000
8		2.570724	0.00112	2.563101	-0.007623	33.143000
9		2.595991	0.00171	2.590601	-0.005390	37.143000
10		2.619963	0.00162	2.616001	-0.003962	41.143000
11		2.643025	0.00156	2.642801	-0.000224	45.143000
12		2.665339	0.00149	2.673201	0.007862	49.143000
13		2.686866	0.00146	2.695001	0.008135	53.143000
14		2.707671	0.00144	2.714301	0.006630	57.143000
15		2.727878	0.00145	2.742301	0.014423	61.143000
16		2.747520	0.00147	2.751501	0.003981	65.143000
17		2.766645	0.00150	2.767001	0.000356	69.143000
18		2.785294	0.00155	2.783301	-0.001993	73.143000
19		2.803501	0.00161	2.804501	0.001000	77.143000
20		2.821297	0.00167	2.818601	-0.002696	81.143000
21		2.838712	0.00175	2.829901	-0.008811	85.143000
22		2.855768	0.00182	2.852501	-0.003267	89.143000
23		2.872489	0.00191	2.868201	-0.004288	93.143000
24		2.888994	0.00199	2.879301	-0.009693	97.143000
25		2.905002	0.00208	2.913901	0.008899	101.143000
26		2.920828	0.00217	2.918101	-0.002727	105.143000
27		2.936387	0.00227	2.943501	0.007114	109.143000
28		2.951694	0.00236	2.950601	-0.001093	113.143000
29		2.966760	0.00246	2.966701	-0.000059	117.143000
30		2.974207	0.00250	2.978801	0.004594	119.143000
SERIAL CORRELATION OF RESIDUALS=SUM(R(I)*R(I-1))/SQRT(SUM(R(I)**2)*SUM(R(I-1)**2))						ALL SUMS ARE FOR I=2,NUMBER OF CASES
SERIAL CORRELATION		RESIDUALS ORDERED ON				
0.46980		CASE NUMBER				

Figure C5. Cont'd.

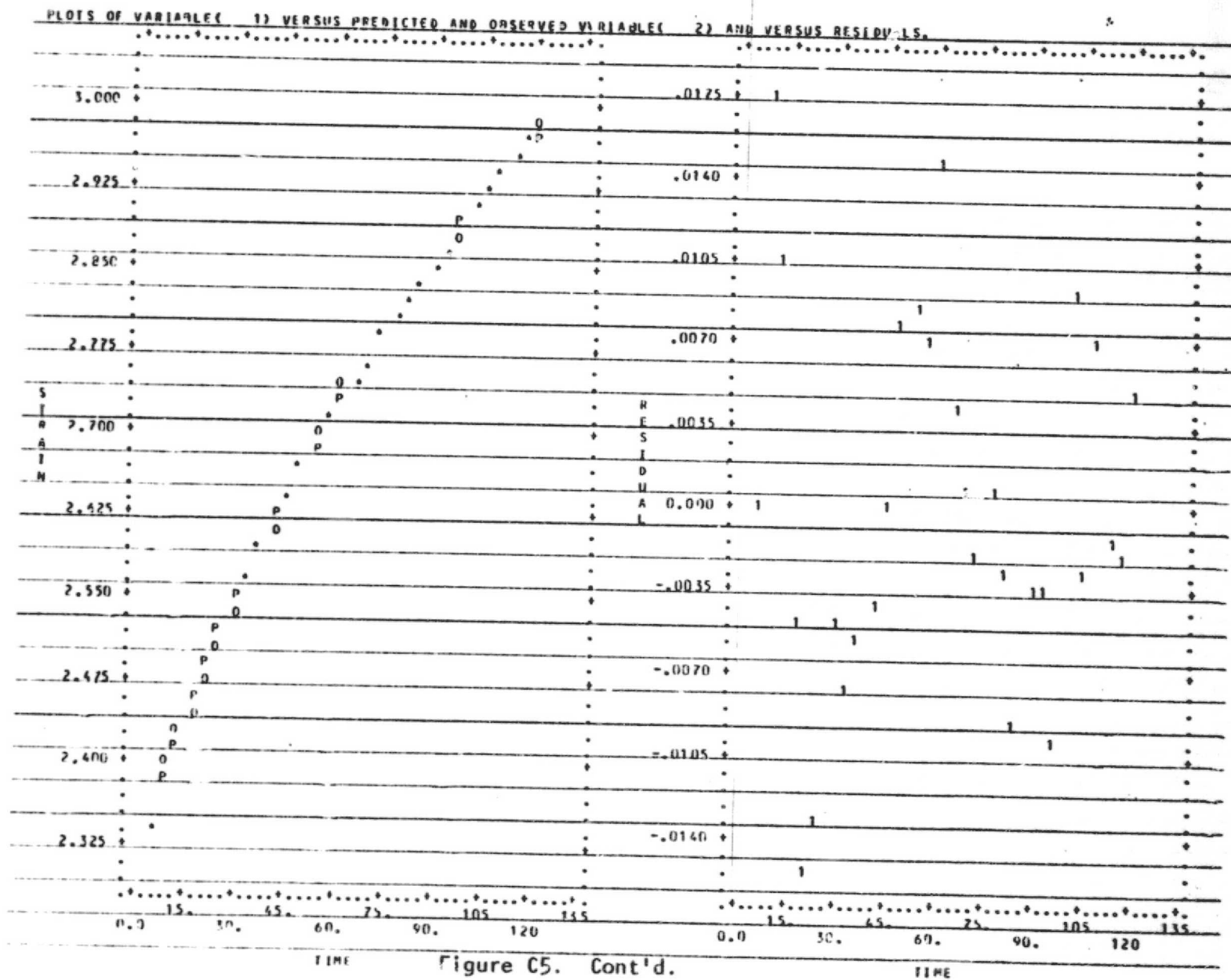


Figure C5. Cont'd.

APPENDIX D

System Components and Performance

In this Appendix, the main components of the creep system are described, and any operational difficulties encountered with these components are discussed.

Creep Frame

The basic loading system used in most of the work was an ATS Model 2410 lever arm tester, with lever arm ratios of 3:1 and 20:1. Spherical couplings were initially used to ensure axially during loading. In later tests, more accurate knife-edge alignment couplings were used.

Furnace and Furnace Controller

For high-temperature testing, a three-zone split furnace, ATS Model 2961, was employed. The original ATS furnace controller gave considerable difficulty. Calibration was very difficult, and system response was highly temperature (set-point) dependent. As a result of these problems, ATS supplied a new digital LFE Corporation controller. This controller worked very well.

Extensometer

Specimens were mounted in an ATS Model 4112 or 4115 extensometer. The extensometer generally worked very well so long as bolts were torqued evenly and not too tightly. Over-torque would cause the bolts to fail in a high temperature test.

LVDT and LVDT Conditioner

Daytronic DS200A transducers were used to measure specimen elongation. Discovered early in the work was a sinusoidal error in the output signals of the two transducers used. One unit was returned to the factory for adjustment, but even after adjustment some error was still present. Since the error in both transducers was a consistent and predictable function of displacement, corrections could easily be made during data reduction.

There were problems of signal drift in the Daytronic 9130 signal conditioner. The problem was somewhat remedied after the unit was re-

turned to the factory. However, for an hour after startup, the conditioner output signal would always drift a small amount before stabilizing. This was accounted for in the routine of test procedures.

Mainframe, Digital Display, Channel Caller

The mainframe unit was a Daytronic system 9005. A 9530 digital display was a part of the system. The digital display was another piece of equipment sent to the factory for repair. In this case, the problem (erroneous readings) was completely corrected. The 9305 A channel caller functioned well at all times.

Thermocouple Conditioner

A Daytronic Model 9110 thermocouple conditioner generally worked well throughout the project. The only problem encountered required nothing more than some minor changes in calibration settings. This raised the accuracy of the component to satisfactory levels.

Chart Recorder

The raw strain-time data were recorded on a Saltec Model B-181 flat-bed recorder. Aside from the creep frame, this proved to be the least troublesome and most reliable component of the system.